POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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A. W. KRAMER, Electrical Editor RICHARD H. MORRIS, Engineering Editor.

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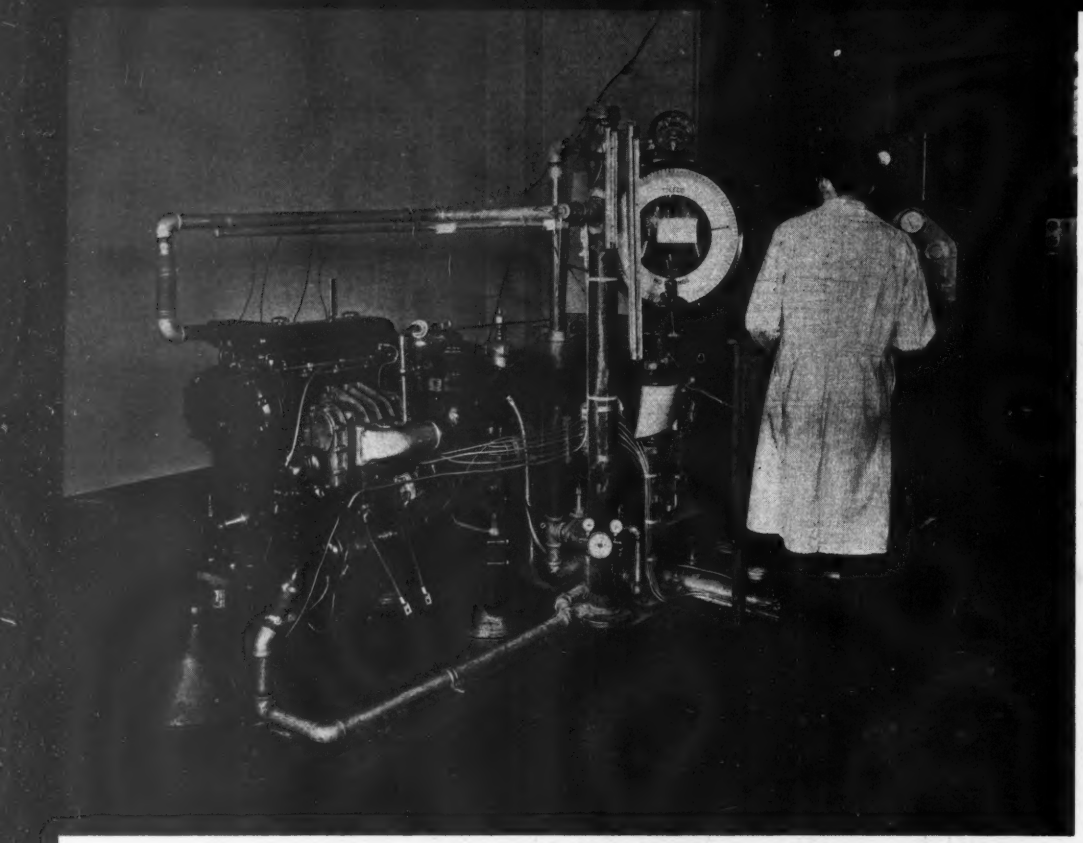

Diesel Clinic

ALTHOUGH the Diesel engine is an inaminate piece of machinery, it has much in common with the human body and ills must be diagnosed and corrected by much the same procedure followed in a modern hospital.

True, Diesels have no tongues to stick out for visual inspection, but they do have temperatures, sensitive digestive and elimination systems and can be made to say Ah-h! with much feeling. They have the capacity to consume vast quantities, and unlike humans, the more their temperature is above normal, the more they consume.

They consume fuel. Not nice, clean, expensive, carefully doped gasoline like their sleek streamlined cousins in the auto, but dirty black stuff—good substantial fodder for a work horse that must pay its way by the work it does and not by its looks and fancy gait. They must work long hours without fatigue, accident or illness.

Of course the Diesel doctor has a simpler job than the human physician for after he has determined the cause for some weakness, corrective steps can be taken in the manufacturing process whereas his compatriot in the hospital has no such control over nature. Furthermore engines are uniform and a detailed clinical research can be made on one picked at random with reasonable assurance that the findings will apply to others of the same type.

To find out how much punishment they can stand, how much they consume, how they react to different fuels, how lubrication affects their rheumatism and other useful and useless information that research men like to accumulate, it has been found advisable to build torture chambers, which, humanized to meet S.P.C.A. standards, are called test laboratories.

At the new Detroit Diesel factory of General Motors the clinical facilities are unusually complete. Test rooms, for engines up to 1200 hp., are each separate, the foundations isolated, the walls covered with acoustic tile and test apparatus complete. Even the power generated on test can be absorbed in the plant system for power or in an electric boiler. The engines built at this factory were described briefly on pages 144 and 145 of the February issue. The photograph shows one of the new engines, well propped up in bed, taking a bit of nourishment under the watchful eye of the nurse.

WITH THE EDITORS

Business

OBVIOUSLY everyone wants better business. Capitalists, both large and small, including savings bank depositors and holders of life insurance policies want better business to give more satisfactory and dependable returns. Business and industrial executives want better business to justify their policies and give them greater rewards for their efforts. Workers want better business so that more jobs and better pay will be available. Even those who object to business as it has been conducted would like to see it improved. The only conceivable objectors to better business are those who argue that all private ownership is wrong in principle and who would welcome anything which would result in ownership or complete control by the government of all business and industry. Even these critics want better business but under a different method of economic organization.

To achieve better business, two things are essential, Confidence and Co-operation. Two main obstacles are Fear and Fighting. Most important is Confidence. Those who furnish capital and those who carry the responsibility for management must have confidence in future conditions if they are to take the risks of doing business.

Reasonable stability in the value of money, regulatory restrictions and the cost factors of doing business or carrying on industry are the basis of confidence. Belief of workers and employers in each other's fairmindedness is the foundation of confidence necessary for the co-operation which is essential for better business.

What is the cause of Fear and Fighting which hold up progress? Just lack of confidence. Mostly in the purposes of human beings. So long as there is doubt of the purposes of those who control industry, either by legislation, or by management of either industry or labor, there will be fear and each will struggle to protect its own interests. As a matter of fact, little progress has ever been made or ever will be made except as the result of self interest. But, any gain made must be beneficial to all, if it is to be of real benefit to the individual. Temporary financial advantage which harms industry will react harmfully on those who take it. The history of topheavy, pyramided holding companies is an example.

What is needed is for leaders in government, capital, management and labor to sit down together, frankly and publicly state their beliefs and purposes, and seek common ground for restoring confidence. This is probably impossible, because of differences in purposes, mostly to gain individual advantage and power.

What then can be done? Business, large and small can make itself heard by government as to what it feels are its needs. Business can take its employes into its confidence as to financial and management problems, and at the same time consider the financial problems of employes.

Business can honestly try to give employes a clear understanding of the relations of capital costs, management costs and labor costs, the benefit of cost reduction to business and the effect of cost reduction on the cost of living, hence on the real value of wages.

Business can try to reach an understanding with honest labor leaders as to how best to benefit workers. Labor racketeers who are more interested in their personal profit than in the interests of those whom they profess to represent need be given no consideration.

Business can adopt a policy of fair division of the proceeds of industry among capital, management and labor and explain frankly the reason for this division.

Business can win the confidence of legislators, investors and workers, in its purposes and methods, if it will adopt purposes and methods that are worthy of confidence and make those purposes and methods plain for all to understand.

With such confidence established, co-operation will be attainable even against the efforts of those who seek selfish advantage. And better business will result.

Action of business as a whole is made up of the actions of separate business organizations, working individually or in co-operation. The ball will start rolling when separate organizations start pushing.

Replace Guessing with Research

IN THE ORDINARY walks of life, the guess is an extremely useful instrument resorted to instinctively by everybody, not only in performing the daily tasks but even in making the more important and less frequent decisions. These instinctive guesses are usually so nearly right that we seldom check up on their importance. We walk, drive our cars, we eat, clothe ourselves—all fraught with dangers if not done properly—yet nobody knows what the exact result will be when we step out of the house into a storm. We warn children under such circumstances to be careful, in other words guess but not wildly, or temper your guess with judgment.

The hazzards of guessing, however, are too great to be ignored and, although it is impossible to get entirely away from guessing, individuals and organizations can help their decisions by carrying on investigations on important subjects with which they must deal. In every power plant there are conditions differing in some respects from those in other plants. Such questions as the most desirable fuel, lubricant, water treatment and program of operation are typical of those which should be studied in each plant. After thorough investigation, the engineer need no longer guess at the solution but will have sufficient information available to give him the correct answer.

Engineers' stock in trade is made up of facts gained through research, mathematics and experience and recorded for reference, thus made available these facts have taken much of the guess work out of engineering and many hazzards, both physical and economic, have been eliminated.

Heywood-Wakefield Co. Burns Pulverized C

New Power Plant for the world's largest manufacturer of seating equipment at Gardner, Mass., operates on wood refuse for a large portion of the day. At times when waste is not available pulverized coal is used.

THE NEXT TIME you travel on a modern bus or on one of the new streamlined trains, look at the name-plate on the back of the seat in front of you; the chances are, you will find, that the seat was manufactured by the Heywood-Wakefield Co. of Gardner, Massachusetts, for this company is one of the largest manufacturers of chairs and seating equipment in the world. Gardner, as a matter of fact, is known as the chair city of the world and is the home of other companies making chairs and seating equipment, but of these the Heywood-Wakefield Co. is the largest. The main office and principal factory is in Gardner but branch warehouses and smaller factories are scattered from Boston to Los Angeles and Portland, Oregon, with a Canadian factory at Orillia.

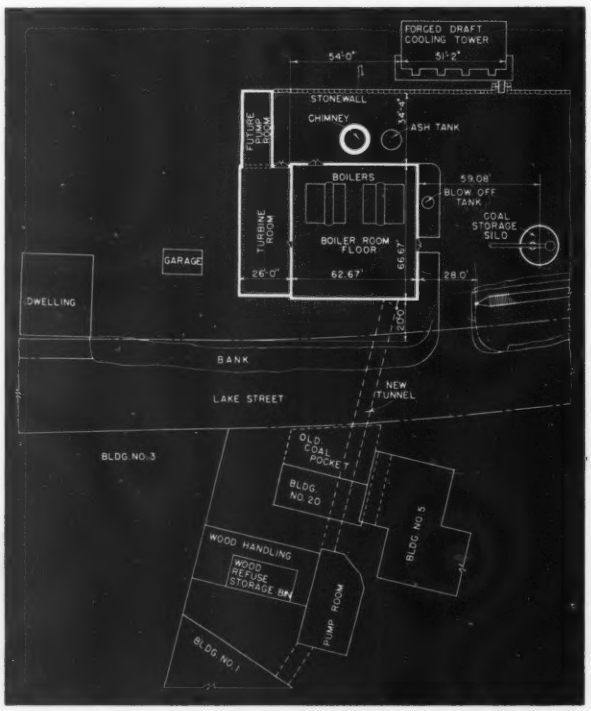

Fig. 1. Plot plan showing location of the new power plant

Ordinarily we do not think of a metal seat in a bus or railroad coach as a chair, but in the trade they are all classified under seating equipment along with household and office chairs. The Heywood-Wakefield Co. make a great many chairs and other wood furniture for the retail trade, but they are also probably the largest manufacturers of car and bus seating in the country and an important factor in the theatre seating market. The car and theatre seating is largely metal, of course, but most of the other seats and chairs made are of wood.

It is this fact, the use of wood, which is of particular interest here since it was an important factor in the design of the new power plant described in this article. When running at capacity, the Gardner factory cuts up a tremendous amount of kiln-dried hard woods, mostly birch and maple. These operations produce a large amount of wood waste—refuse which must be disposed of and which provides an economical fuel for use in the power plant. This refuse runs to a maximum of around five tons per hour.

Until the new power plant was built during 1936 and 1937, this manufacturing plant was served by an old power plant using H.R.T. boilers, one engine driven generator and one turbine-driven generator but as has been the case in many industries which have grown rapidly, this power plant had become inadequate in latter years and a considerable amount of power was purchased.

Several years ago, therefore, it became evident that a new plant was desirable, and after preliminary discussion, Francis J. Sill, consulting engineer of Westboro, Massachusetts, was retained to design and construct a new power plant which would produce all the steam and electrical energy needed by the manufacturing plant. This project involved not only the new power plant but also a new tunnel carrying all services to the factory. The tunnel alone was a construction project of no mean importance since much of its length had to be blasted out of solid rock.

This new power plant which now has been practically completed comprises a new building together with a

d Coal and Wood Refuse

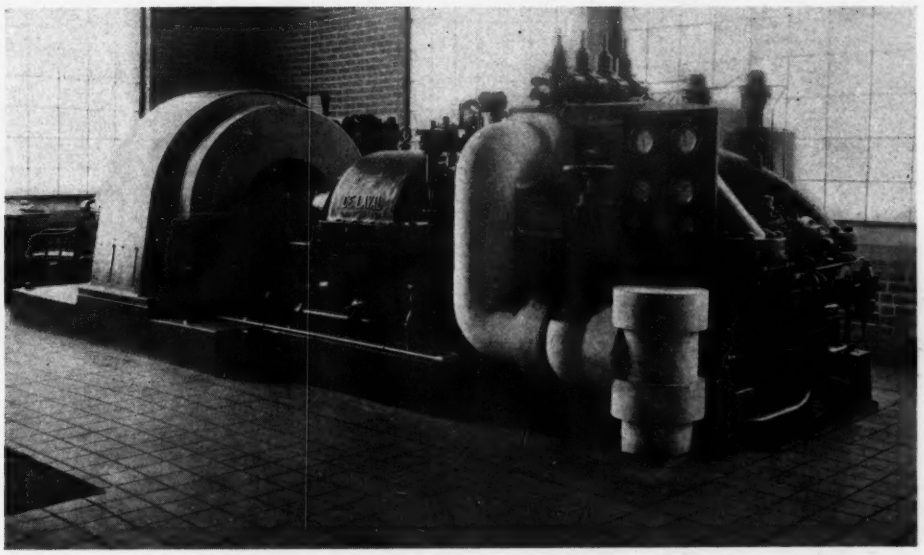

Fig. 2. The main turbine-generating unit. This is an 850 kw. unit, designed for full condensing operation with extraction at 10 lb. It is a geared unit, the turbine operating at 6060 r.p.m. and the generator at 1200 r.p.m.

radial brick stack and complete coal and ash handling equipment. The final design also includes a cooling tower and a new pump room for the associated pumping equipment but this has not yet been built.

The boiler room containing the first boiler with space for a second was completed early in 1937, Since that time, however, the turbine room has been added and now the second boiler is being installed. The turbine room at present contains two generating units, one a main unit of 850 kw. capacity arranged for extraction at 10 lb. and full condensing, but being operated on straight back pressure temporarily until the condensing equipment is installed in the near future; secondly, a standby unit of 170 kw. capacity designed for permanent operation at 10 lb. back pressure. Provision is made for the installation of another large turbogenerator in the near future. All power required will then be generated by the new power plant.

Aside from the electrical energy needed in both the wood and metal working processes in the factory, there is a considerable demand for steam. For heating the dry kilns there is a continuous year 'round demand for steam of considerable proportion. During factory operating hours there is also a very large steam demand for wood bending and various drying operations. Added to this, in the heating months is a large demand for steam for building heating since some 26 acres of floor space are involved in the factory layout. All this adds up to a steam load during factory hours amounting to about 50,000 lb. maximum, a major portion of which will be low pressure. The electric load in the plant is in the neighborhood of 1500 kw. As mentioned above, part of this electrical load has been purchased in the past.

These steam and electrical requirements together with the fact that a large amount of wood waste was available determined the desirable objectives in the design of the power plant. These objectives were:

(a) To attain the most flexible and efficient wood burning scheme possible.

(b) To be able to supplement the wood with coal at high efficiency when necessary.

(c) To generate steam of a quality which would permit making most of the electricity required as a by-product in the reduction of steam to the proper pressures and temperatures required by the factory.

Although the plant has not yet been entirely completed and at the time of this writing the boiler has been operating at the designed pressure and superheat for only about a month, preliminary operating results indicate that the objectives will be achieved. From the wood preparation and storage facilities to the turbine room and switchboard, the equipment is operating satisfactory and with good economy. The combustion on wood fuel alone is giving better than 12 per cent CO_2 and on coal alone 15 per cent or better.

The fact that both wood and coal had to be used as fuel either singly or in combination complicated the combustion problem. In many other power plants of a similar type where both coal and wood are burned, the coal is burned on grates or stokers and the wood

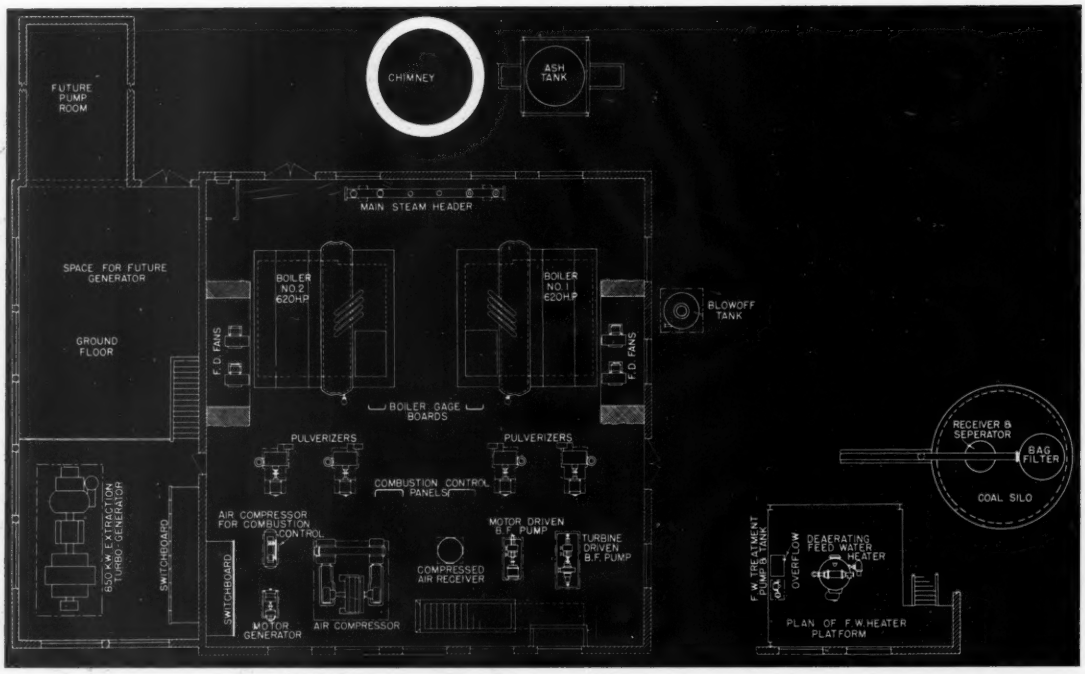

Fig. 3. Plan of power plant. This plan shows the boiler room operating floor which is the ground floor, and the turbogenerator on the second floor of the turbine room.

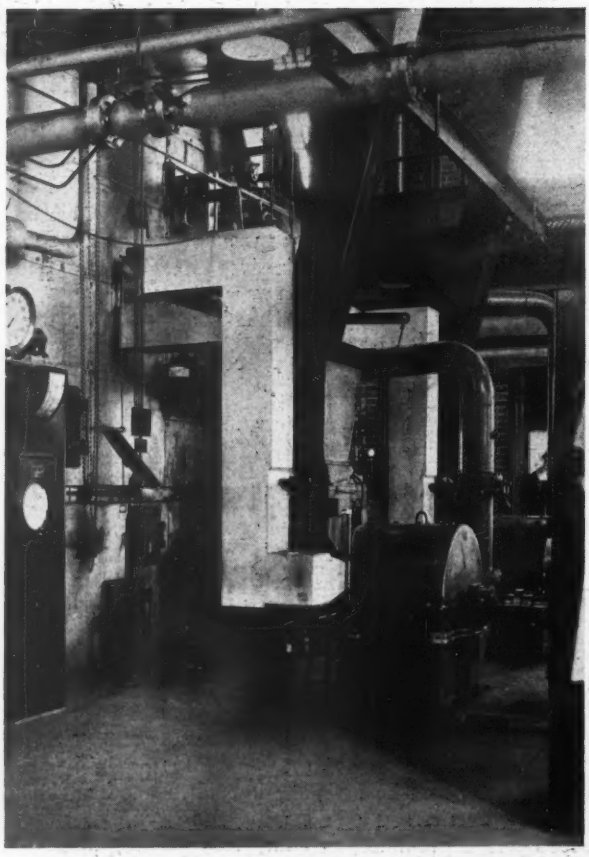

Fig. 4. A view of one of the boilers, showing the pulverizing units in the foreground.

merely dropped from above, burning either in suspension or on the grates. In this case, however, it was desired to use wood alone during many periods and this made it necessary to eliminate stokers. Also, there was the problem of introducing wood into the furnace without interfering materially with the turbulence necessary for proper combustion of pulverized coal.

The boilers selected are integral furnace, B. & W. units, fired by Riley pulverized coal burners, two burners per boiler. These burners are installed vertically in the front wall of the furnace. The wood is introduced at the top of the furnace on one side with forced draft fans and secondary air ducts for wood burning arranged at the side as shown in Figs. 5 and 6. These air ducts introduce air near the bottom of the furnace so as to limit the wood piling up on the floor of the furnace. The arrangement is clearly shown on the drawing. Wood chips that do not burn completely before they reach the bottom of the furnace are carried across the bottom of the furnace by the air issuing from the secondary ducts and up at the opposite side.

The design of the wood transport system between the factory and the power plant involved interesting considerations. The wood refuse at this factory is collected in a steel storage bin having a capacity of some 12,000 cu. ft. This bin is associated with a low pressure air conveying system which takes wood away from the bottom of the shredder and discharges it into the storage bin.

Thirty spiral conveyors are installed in the storage bin which act as a live bottom for taking wood out of storage in varying quantities. These conveyors are motor driven in batteries of three so that wood can be taken out of storage in amounts varying from 1 to 10 batteries. These batteries are remotely controlled from

the boiler room. This equipment also includes a motor driven conveyor for gathering the wood from the 30 conveyors and delivering it to an air lock.

This much of the system is quite simple and conventional. The real problem involved in the design of the system was in the transport system from the air lock to the boiler house. It was desired to carry the wood from this collecting center to the plant by means of air but to avoid upsetting combustion conditions it was necessary to use as little air as possible in the conveying process. This meant high pressure and a small transport line.

Since the character of the wood waste was a factor in the size of the line, a study was made and it was found that the largest chips to be handled were 5 in. long. With this as a starting point, a 6 in. pipe line was decided upon.

Next, the theoretical air requirements for combustion of the minimum normal load were determined and the quantity of air thus arrived at was considered to be the quantity available for transport use. The final step in the process then was the determination of the proper air pressure under which this minimum quantity of air would carry the wood through the pipe.

With the system designed on these principles, the size of the transport line is very small compared to conventional systems and the amount of air introduced into the furnace by the transport system is low enough not to support combustion. Since the air was figured on a theoretical basis, all additional air needed for proper combustion must be supplied as secondary air by the forced draft fans. The transport system itself includes an air lock for receiving the wood from the Jeffrey gathering conveyor and a motor driven blower for forcing the wood through the 6 in. pipe line into the

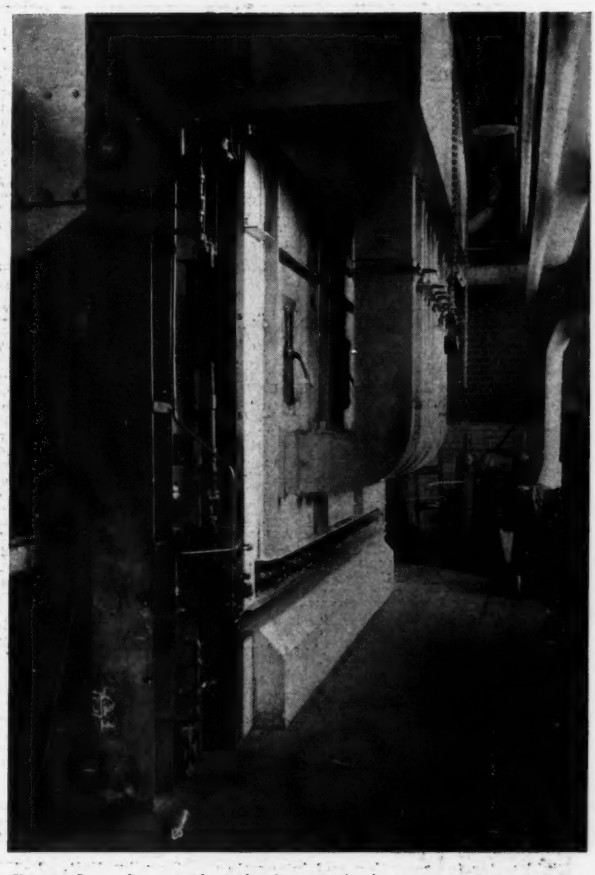

Fig. 5. Secondary air ducts leading to the lower part of the furnace. The forced draft fans are located immediately above the main duct shown at the top

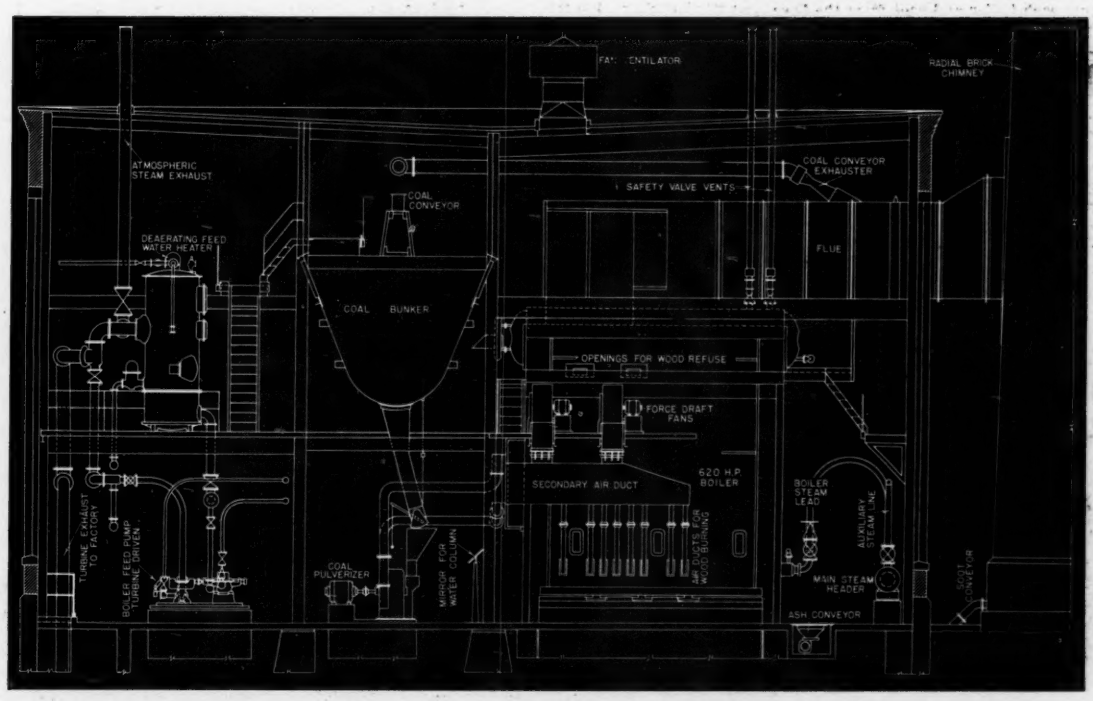

Fig. 6. Cross section through the boiler room. This shows the arrangement of the coal bunker and the feed water heater. Also, note the arrangement of the secondary air duct and the forced draft fans referred to in Fig. 5

Principal Equipment in the Power Plant of the Heywood-Wakefield Co.

GENERAL

Location, Gardner, Massachusetts
Owner, Heywood-Wakefield Co.
Industry, Chair and seating equipment manufacturing
Consulting Engineer, Francis J. Sill, Westboro, Mass.

Boiler Room Equipment

Boilers: 2 Integral furnace boilers, 6233 sq. ft. H.S. each, designed for 300 lb. w.p., 200 deg. F. superheat. Maximum cap. 60,000 lb. per hr. Operating pressure 275 lb. gage. Babcock & Wilcox Co.
Pulverizers and burners. 2 motor driven pulverizers and 2 burners per boiler. Riley Stoker Co.
Pulverizer motors. Westinghouse 40 hp.
Forced draft fans. 2 per boiler. Clarage, Type W with Vortex inlet. Clarage Fan Co.
Forced draft fan motors. Westinghouse, 7½ h.p.
Boiler Feed pumps. 2, Centrifugal, 60,000 lb. per hr. at 370 lb. discharge press. (each). Pennsylvania Pump and Compressor Co. One is driven by a Whitton steam turbine and the other by a Westinghouse motor.
Feedwater Heater. 1 Deaerating type, cap. 60,000 lb. per hr. Temp. of water leaving heater 235 deg. F. The Elliott Co. Boiler settings. Sectionally supported walls composed of tile of 7 and 9 in. thicknesses, 2 in. block insulation and steel panels. American Arch Co.
Combustion Control. Hagan Corporation
Feedwater Regulators. Copes, 2½ in., 60,000 lb. per hr., Northern Equipment Co.
Excess Pressure Regulator. 2½ in. differential control for excess pressure feedwater leaving motor driven boiler feed pump. Cap. 60,000 lb. per hr. Copes. Northern Equipment Co.
Water Columns. Diamond
Soot Blowers. Diamond
Blow-off Valves. Yarway
Safety Valves. Consolidated Ashcroft.
High Pressure Steam and Water Valves. Chapman (gate valves) Edward (globe and check valves)
Boiler Instruments
2 Bailey boiler meters for indicating, recording and integrating the rate of steam flow and recording the relative rate of air flow and flue gas temperature
2 Multipoint draft gages
1 Fluid meter for recording and integrating the rate of flow of feed water to the boilers. Bailey Meter Co.
Feedwater Treatment. Hall Laboratories

COAL AND ASH HANDLING

Ash Handling. Steam pneumatic system. Capacity 10 tons per hr. Removes ashes and soot from each boiler and soot from the base of the chimney. A motor driven dustless unloader is installed under the ash tank. United Conveyor Corp.
Coal Handling. Steam pneumatic. Capacity 20 tons per hr. Removes coal from railroad cars by suction and delivers it either into the coal storage silo or direct to coal bunker in the boiler room. United Conveyor Corp.
Redler System. For conveying coal from the storage silo to the coal bunker. Capacity 30 tons per hr., Stephens-Adamson Mfg. Co.
Coal storage silo. Capacity 250 tons. Outside diameter 20 ft., height 55 ft. Stephens-Adamson Mfg. Co.
Driving motors for coal handling equipment. 7½ h.p. Westinghouse.

WOOD HANDLING EQUIPMENT

Wood Refuse Storage Bin. Steel. Capacity 12,000 cu. ft. Berlin Construction Co.
Low Pressure Wood Refuse Conveyor System—Consists of a motor driven fan that takes wood away from the bottom of the shredder and discharges it into the wood refuse storage bin. B. F. Sturtevant Co.
Wood Shredder. 36 by 60 in. Capacity 5 tons per hr., Jeffrey Mfg. Co.
Wood Shredder Motor. 150 hp. Synchronous. Electric Machinery Co.
Wood Storage and Reclaming Equipment. Consists of storage bin with 30 spiral conveyors. Conveyors are motor driven in batteries of three so wood can be taken out of storage in varying amounts from 1 to 10 batteries. Jeffrey Mfg. Co.
High Pressure Pneumatic System. System includes an air lock receiving wood from the gathering conveyor and a motor driven blower for forcing air through 6 in. line to boilers. Maximum capacity 9000 lb. wood per hr. United Conveyor Corp.

TURBINE ROOM EQUIPMENT

Main Generating Unit. 1—850 kw. extraction turbine, 10 lb. extraction, and full condensing driving generator through speed reducer. Turbine speed 6060 r.p.m. Turbine designed for 275 lb. 200 deg. superheat. De Laval Steam Turbine Co.
Generator. 850 kw.-1200 r.p.m. 600 volt 3 phase-60 cycle 80 per cent power factor alternating current generator with 20 kw. direct connected exciter. Electric Machinery Mfg. Co.
Standby Unit. 1—170 kw. turbine. 275 lb. pressure. 200 deg. F. superheat arranged for 10 lb. back pressure operation, driving generator through reducing gears. Turbine speed 7160 r.p.m. De Laval Steam Turbine Co.
Generator. 170 kw.-1200 r.p.m.-600 volt-3 phase 60 cycle 80 per cent power factor, alternating current generator with direct connected exciter. Electric Machinery Mfg. Co.
Condensing Equipment. Forced draft cooling tower, surface condenser, condensate, circulating water and air pumps. Condenser to operate at 3 in. HG. Abs. C. H. Wheeler Co.
Turbine Oil Purifier—De Laval Steam Turbine Co.
Electric Switchboard. G. and N. Engineering Co. General Electric equipment.
Turbine Room Crane. Hand Operated. Capacity 5 tons. Whiting Corp.

PUMPS AND COMPRESSORS

Main Air Compressor. 1 Horizontal Duplex two-stage, air compressor. Capacity 755 c.f.m. 100 lb. pressure. Chicago Pneumatic Tool Co.
Compressor Motor. Synchronous, 150 hp., 80 per cent leading power factor. Electric Machinery Mfg. Co.
Compressor for Comb. Control Loading Pressure—Quincy 2 stage—vertical—80 lb. operating pressure, 11.8 C.F.M. actual free air—3 hp. motor. Westinghouse.
Service Pumps. 2—centrifugal, 340 g.p.m., 90 lb. discharge pressure. Worthington Pump & Machinery Corp.
Service Pump Motors. 30 hp. each. Westinghouse.
F. W. Treating Pump. 1—motor driven vertical single acting plunger pump used for discharging boiler feed water treating solutions into feed line. Goulds Pumps, Inc.
Vacuum Return Pump. Capacity 140 g.p.m., 45 lb. discharge pressure. Nash Engineering Co.

MISCELLANEOUS EQUIPMENT

Steam Desuperheater. 50,000 lb. per hr. cap. used for removing superheat from steam for factory. Elliott Co.
Desuperheater Control. Mason Neilan Regulator Co.
Steam Flowmeters for steam to turbines and factory. Bailey Meter Co.
Pressure Reducing Valves. 3, for reducing pressure of steam to factory. Mason Neilan Regulator Co.
Relief Valves. 4, to protect deaerator and turbines. Cochrane.
Heat Insulation. Philip Carey Co.
Piping. Jennison Co.
Pressure Gages and Thermometers. Foxboro Co.
Erection of Boiler Settings. Oscar F. Carlson Co.
Building Contractors. E. J. Cross and Wiley and Foss.
Electrical Installation. Warren and Bigelow Electric Co.
Breeching and Flue. D. M. Dillon Steam Boiler Works.
Air Ducts, platforms and coal chutes. Jennison Co.
Chimney. Natural draft, radial brick. Total height from top of foundation. 190 ft. Internal top diameter, 8 ft. The M. W. Kellogg Co., Inc.

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boilers. The maximum capacity of this system is 9000 lb. of wood per hr.

General Arrangement

The general arrangement of the plant is indicated in the accompanying drawings. As shown, the plant consists of a main building containing both boiler and turbine rooms, with an extension on the ground floor of the turbine room to serve as a pump room for the cooling tower now being erected. The main turbo-generator is located on the second floor of the turbine room while a smaller unit for night and standby service is installed on the ground floor. The operating floor in the boiler room is on the ground level.

The two 620 hp. boilers are installed side by side, each with two pulverizers directly in front. The overhead coal bunker runs the entire length of the room,

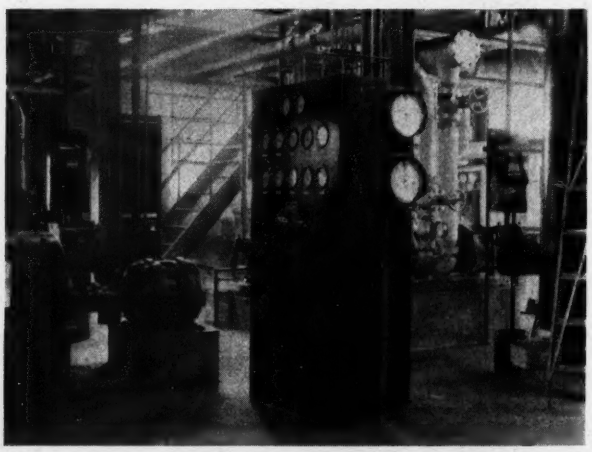


Fig. 8. The combustion control panel

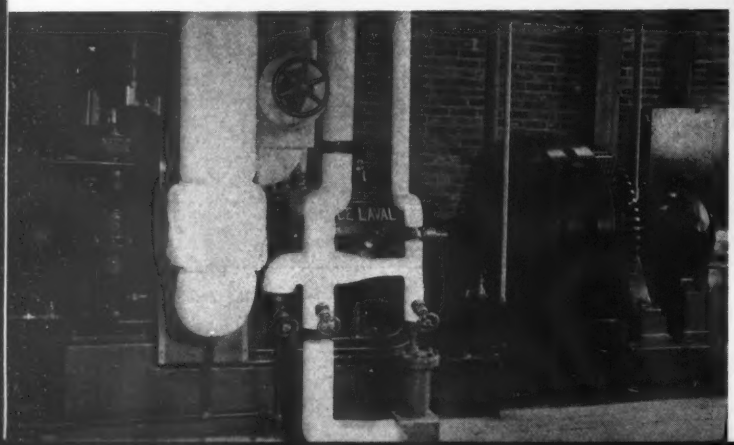


Fig. 7. The stand-by generating unit

coal being drawn from this bunker directly into the pulverizer feeders below. The two boiler feed pumps, one turbine driven and the other motor driven, are placed behind the pulverizers as indicated.

On the other side of the room is an electrically driven horizontal duplex air compressor, delivering 100 lb. air to the factory. Alongside of this unit is a small motor generator set for supplying a small amount of direct current, and a small motor driven air compressor mounted integral with a receiver for furnishing air loading pressure for the combustion control system.

The switchboard controlling the electrical circuits is divided into two parts, one half located on the second floor of the turbine room near the main turbogenerator and the other half on the ground floor of the boiler room near the air compressor as shown.

This arrangement was imposed partly by the fact that the boiler room was built before the turbine room was started. The board in the boiler room contains the feeder panels for all the boiler room electrical equipment. The board in the turbine room contains the generator and exciter panels and the feeder panels for the factory circuits. This arrangement is flexible and convenient since it places the boiler room circuits directly in control of the boiler room operators and since the two sections of the board are in comparatively close spacial relation, being separated virtually only by a floor, it was only a little more expensive to install.

The deaerating feed water heater is mounted on a concrete platform directly above the boiler feed pumps.

Fig. 9. The wood collecting center

This platform connects with the turbine room operating floor by means of a walkway alongside of the coal bunker as shown in Fig. 10.

Each boiler is provided with two forced draft fans for supplying the secondary air needed in burning wood and also coal. These are motor driven Clarage fans mounted on a platform at the side of and near the top of the boiler. These fans feed into a common secondary air duct from which a number of smaller ducts deliver the air into the lower part of the furnace as shown in Fig. 5. No induced draft fans are needed as sufficient natural draft is provided by the 190 ft., 8 ft. diameter radial brick stack which forms a part of the new project.

Coal handling at this plant involves two separate systems, one a steam pneumatic coal conveyor with a capacity of 20 t. per hr., removing coal from railroad

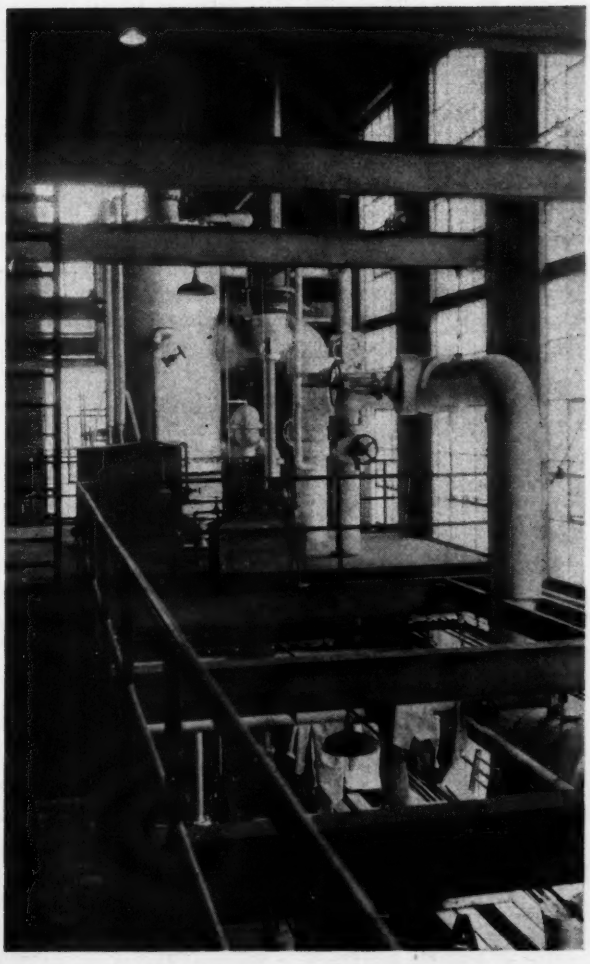


Fig. 10. View in the boiler room showing the feed water heater

cars and delivering it either into the coal storage silo (outside) or direct to the coal bunker in the boiler room. The other is a "Redler" motor-driven horizontal coal conveyor conveying coal from the coal storage silo to the coal bunker in the boiler room. This conveyor has a capacity of 30 t. per hr. The coal storage silo is 20 ft. in diameter and 55 ft. high, providing capacity for storage of 250 t.

Ash is also handled by a steam pneumatic conveying system. This conveyor has a capacity of 10 t. per hr. and removes ashes and soot from each boiler and soot from the base of the chimney. A motor-driven dustless unloader is installed under the ash storage tank. As shown on the drawings the ash storage tank is located adjacent to the chimney.

The wood handling system has already been described. It is unique in the small size of the pipe used to transport the wood. As previously mentioned, the 30 spiral conveyors used for taking the wood out of the storage bin and delivering it to the air lock for further transport to the boiler room are remotely operated from the boiler room. The conveyors are arranged in batteries of three, and are provided with indicators in the form of neon lamps in the boiler room so that the boiler operator by looking at these lamps can know whether a certain portion of the storage bin is

empty or not. These indicating lamps together with the push buttons controlling the conveyor motors are mounted on a small panel near the boilers.

Boilers

Each of the two integral furnace boilers designed for 300 lb. working pressure, at 200 deg. F. superheat, have a maximum capacity of 60,000 lb. of steam per hr. At the present time they are being operated at 275 lb. pressure. Each boiler has two pulverized coal burners each supplied by its own pulverizer. Heated air for the pulverizers is drawn from between the front furnace walls.

Control of combustion when burning coal is automatic by the Hagan system of control. A control panel containing the necessary controls and indicators is mounted in front of each boiler. In addition, another panel carries a boiler meter and a multipoint draft gage for each unit and a fluid meter for recording and integrating the flow of feed water to both boilers.

Fig. 11. Exterior of the Power Plant

High pressure, superheated steam is delivered to a main boiler header mounted near the floor at the rear of the boilers, from which headers lead to the turbine room and to the factory. Another distributing header is located on the ground floor of the turbine room from which leads to the turbines are connected.

Low pressure steam for the deaerating feed water heater is normally obtained from the exhaust of the main turbine but in case this is insufficient, steam is taken from the high pressure system through reducing valves and desuperheaters. This control is automatic; if the pressure of the feed water, in the deaerator drops below a minimum value a regulator acts to bypass steam from the high pressure system.

Steam for use in the factory is desuperheated by means of an Elliott desuperheater having a capacity of 50,000 lb. of steam per hr.

Electric Generation

The two turbogenerators at present operate non-condensing against 10 lb. back pressure but the large unit, which is designed for extraction at 10 lb. and full condensing, will be provided with a surface condenser in the near future. Since no suitable condensing water supply is available, a cooling tower is necessary and just as soon as this is completed, the condensing equipment will be installed.

The small generating unit located on the ground floor is rated at 170 kw. and designed for back pressure operation at 10 lb. Like the large unit on the floor above, it is a De Laval machine driving the generator through reducing gears. The turbine speed of this unit is 7160 r.p.m., the generator speed, 1200 r.p.m.

The main unit is rated at 850 kw., 80 per cent power factor. In this case the turbine speed is 6060 r.p.m. and the generator speed 1200 r.p.m.

Generators in both cases are Electric Machinery Co. units with direct connected exciters. An emergency tie with the local power company is maintained through a bank of transformers located outside the building but the generators ultimately will be adequate to supply all loads. Provision is made for the future installation of another generating unit and in all probability it will be a larger unit than the one now in operation. With this provision, the electrical supply of the factory is assured for a long time to come.

Conclusion

This concludes a general description of the principal features of this plant. Further details regarding the equipment will be found in the accompanying list of equipment and in the drawings and photographs. It is a fine example of a modern industrial type of power plant, furnishing both steam and electrical energy to a growing factory. A plant of this kind is bound to prove economical, since the wood waste used for fuel would have to be disposed of in any event and by means of a power plant such as this it is converted into steam and electrical energy. Despite the short time it has been in operation under the capable supervision of R. G. Macintyre, the chief engineer, this plant has already proved its merit.

In conclusion we wish to express our appreciation to the management of the Heywood-Wakefield Co. for permitting our representatives to visit and inspect the plant and to Francis J. Sill, the consulting engineer, for many courtesies and assistance in supplying data used in the preparation of this description.

Progress from 1838 to 1938 in lighting, transportation and living conditions is well summarized and graphically portrayed by the text, illustrations and unique memorabilia given in a 32-p. rotogravure section of the Louisville, (Ky.) Courier Journal for Feb. 13th. It shows the progress of public utilities during 100 yr. of service, from the days when gas lights, ox carts, stage coaches and river steamboats were prominent in the daily life of Louisville, up through early developments in electric lighting and railroading, the exciting days of the Civil War with mule-drawn street car systems, to perfected electric lighting, gas for heating and cooking, automobiles, fast railroad trains and electric street cars. Romance permeates the pages, not only in the changes in utility services but also in the intimate pictures of important personages and social events which have made Louisville one of the most interesting cities in the country. Copies of the review may be had from Robert Montgomery, vice-president, Louisville Gas & Elec. Co., Louisville, Ky.

Modern Pressure Reducing and Desuperheating Practice

Part I. All engineers—industrial, central station or consulting—concerned with modern stations must face some phase of this problem—a problem old in itself yet assuming new proportions as higher pressures and temperatures increase the differentials between plant elements and more exacting conditions of operation demand high capacity, high operating speed and accurate regulation of pressures and temperatures. Part I deals with the fundamental equipment and its application in simple form, Part II deals with some recent refinements found necessary to meet specific conditions of operation.

By Chester R. Earle, Engineer
Republic Flow Meters Co.
Chicago, Ill.

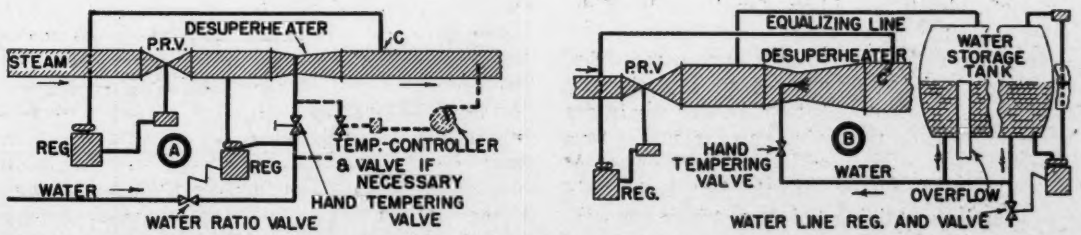
PRESSURE REDUCING and desuperheating are closely related to operating control of the power plant. The principles and many of the fundamental methods used in carrying out these two operations are not new, but, the gradually increasing steam pressures and temperatures during the past 15 yr. have changed the pressure and temperature differentials between various parts of the plant to such an extent that the combined problem has assumed new proportions. The two operations are carried out for a greater variety of purposes than formerly. Furthermore, the necessity for coping with higher and higher pressures, temperatures and capacities has brought about many improvements in the design of the equipment itself, as well as many new and ingenious methods of controlling this equipment automatically. Availability of the pressure reducing and desuperheating equipment must be high to match that of the main boiler and turbine units.

The following comments cover the recent practices of one manufacturer in designing, building and installing pressure reducing and desuperheating equipment, with its related automatic controls, in a number of the country's newest central stations and industrial power plants, most of them high-pressure plants, many of them topping plants. Control of steam temperature at the boiler outlet will not be discussed here, for it was treated in some detail in the January, 1938, Boilers and Furnaces Number of POWER PLANT ENGINEERING.

FUNDAMENTAL EQUIPMENT

In any particular installation, the equipment itself consists of a number of standard elements but these are connected and controlled in a manner dependent on the requirements of that particular plant. In some cases, the fundamental equipment alone meets all the needs; in other cases, special types of master control, special safety devices and other refinements are employed. First consider the fundamental equipment itself. As shown diagrammatically in Figs. 1A and 1B this consists of pressure reducing and regulating valves, desuperheaters and the regulators that control them.

Pressure reduction and regulation are carried out by turbine-type valves under the control of regulators. Such valves, designed especially for regulating service, are either lever-operated or cylinder operated. In the latter case, a powerful hydraulic system, controlled by a regulator, applies oil pressure to a piston mounted directly on the valve stem. The regulator is controlled from the



Figs. 1A (left) and 1B (right). Fundamental arrangement of the pressure reducing and desuperheating equipment discussed in this article. Later illustrations show refinements and extensions necessary to meet specific operating conditions in many new industrial and central station plants. The tank arrangement on the right is used with quick opening bypasses to provide for instant water flow and for emergency water storage

The pressure drop from the entrance to the throat of the venturi is a measure of the steam flow, and, in both Figs. 1A and 1B, this pressure differential is used to control the flow of desuperheating water so that it is proportional to the steam flow at all loads. Although the two flows are proportional to each other because they are both proportional to the same pressure differential, the proportion may not be the proper one to give the desired results because the quantity of water needed depends upon the initial and final steam condition as well as the steam flow. Therefore an adjustment is provided by means of the hand tempering valve. This acts in the nature of a fixed but adjustable orifice in the water line and is changed only when the initial or final steam conditions are changed. If the initial steam temperature fluctuates constantly a temperature controller may be added, as shown dotted at the right of Fig. 1B, to control a small valve in the bypass around the hand tempering valve. This is equivalent to an automatic temperature control on the hand tempering valve and gives close temperature regulation without sacrificing the low time lag advantage inherent in the ratio control. Details of the design and operation of the regulators used are described by Fig. 4 on page 278 of the May 1936 issue of Power Plant Engineering.

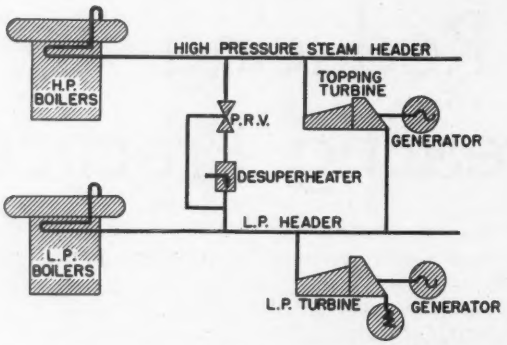


Fig. 2. Typical arrangement of pressure reducing and desuperheating station for bypassing topping turbines in industrial plants and central stations

This avoids an interruption of steam flow to the low pressure system in case the topping turbine trips out or is down. This is fundamentally the same as the arrangements made to tie an old plant to a high pressure condensing extension so as to carry all or part of the low pressure load with the newer more efficient boilers, or, what is more common, enable the old turbines to be kept as standby to be supplied with steam from the new boilers in emergencies or when the new turbine is down. The only difference in the two cases is that the topping turbine shown above would be a condensing turbine. Either of the fundamental arrangements shown by Fig. 1 can be used.

pressure in the pipe line at the point (C in Figs. 1A and 1B) where the required low pressure is to be maintained.

The venturi spray type desuperheater, used in all the plants referred to in this article, is a straight-line venturi, self-supported in the pipe line and containing a water spray nozzle, located so that the desuperheating water is sprayed into the steam at the point of maximum velocity, to insure complete evaporation of the water.

One of the principal characteristics of this unit is that the water spray is automatically controlled by the steam flow through the venturi so that the water is proportioned to the steam flow at all times, to produce the required temperature reduction. This is done by utilizing in two different ways the pressure drop created at the venturi throat by the steam flow. This pressure drop is a measure of the rate of flow and is applied to control the spray water either by actuating a regulator to operate a valve in the spray water line, as in Fig. 1A, or, by causing the spray water to flow from a water reservoir, as in Fig. 2B. The second, known as the tank type, is sometimes used with quick-opening bypasses (discussed in Part II) to insure instant flow of water to the desuperheater the instant steam flows, without movement of valves or parts, also to provide a stored supply of desuperheater water for emergencies.

The foregoing methods of control, termed ratio control, are entirely satisfactory when steam conditions on the high side are constant. If the high side conditions vary, however, a second tempering valve, actuated by a temperature controller, as shown dotted at the right of Fig. 1A, is placed in parallel with the first, acting as a vernier on it and maintaining the downstream temperature constant. The desuperheater spray water can, of course, be controlled by a temperature controller alone if the conditions warrant, as in some auxiliary desuperheaters or in a desuperheater placed in a turbine exhaust or extraction line to protect downstream equipment if the steam temperature in the turbine rises at low load.[1] Temperature control, however, has inherently a high time lag; the ratio control, on the other hand, responding to pressures that change instantly when flows change, has inherently a minimum of time lag.

It is obvious that the physical arrangement of the equipment will depend on many factors of plant design and layout. In many cases, pressure reducing and desuperheating are carried out together—that is, the desuperheater follows the reducing valve as closely as the equipment design permits. But in other cases they are separated,[2] the pressure reduction being carried out in one header system, the desuperheating in another. Occasionally the plant conditions are such that only one of the operations, either pressure reduction or desuperheating, is necessary.

A typical bypass for a straight back-pressure topping turbine is shown in Fig. 2. This is one of the most modern applications and is being employed by a number of the most recent plants. First of all, such a by-pass must shut off tightly when the topping turbine is in operation. But if the turbine trips out, the bypass must open rapidly to pass the high-pressure steam to the low-pressure system at reduced pressure and temperature, confining the loss of load to that carried by the topping turbine and permitting all the rest of the plant, high pressure boilers and low pressure equipment, to continue as before. In the central station top, as much electrical load as possible must be carried; in the industrial topping plant, this may also be important but, in addition, steam pressures and temperatures in various process headers must be maintained, otherwise some of the manufacturing operations may be disturbed.

In industrial plants, as pointed out above, the problem of connecting various pressure systems through pressure reducing valves and desuperheaters is an old one. Steam must often be supplied to supplement either turbine exhaust or extraction. In a few recent new industrial power plants, no low-pressure boilers whatever are installed. Instead, all steam is generated at high pressure, 400 lb. and sometimes 600 lb., and the required process pressures obtained by extraction or

[1]Editor's Note. See Fig. 3, p. 56 Jan. 1938 issue of Power Plant Engineering. This increase in exhaust temperature at low loads occurs in a turbine operating at constant back pressure, whether in topping, straight back pressure or condensing operation due to the throttling action of the governor and lower turbine efficiency at light loads. The temperatures at extraction points, and at the cross over point of a compound turbine, decreases at low loads because of the lower stage pressures throughout the machine.

[2]Editor's Note. See Fig. 1 page 644 Nov. 1937 issue of Power Plant Engineering for an interesting case of this kind where superheated steam for auxiliary drives is taken off between the reducing valve and desuperheater.

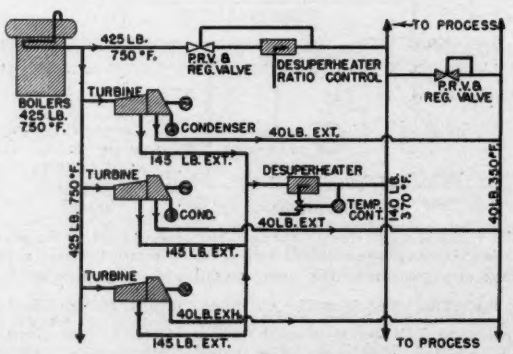


Fig. 3. A typical industrial plant using two process pressures

Steam for process is obtained from a combination of extraction, turbine exhaust and pressure reducing station. Note the use of a separate desuperheater with temperature control to guard against excessive steam temperatures from the high pressure extraction points.

exhaust from steam turbines. Condensing extraction turbines are frequently used for this service. Figure 3 shows a typical plant of this type.

Industrial process steam and electrical demands vary so widely that a typical layout is difficult to make. There may be two, three, or four separate low pressure systems; in such cases, pressure reducing stations can be connected so that the pressure, flow or temperature or various combinations thereof can always be maintained from the next higher pressure system. One such plant has a condenser that is cut in automatically when the flow of steam in one of the systems exceeds a predetermined amount.

One important consideration is that, in many cases, pressure reducing and desuperheating equipment designed for strictly emergency conditions, such as topping turbine bypasses, must often be operated under severe conditions for extended periods during the construction and preliminary operation of the station. It may become necessary for the high-pressure boilers to operate and supply steam to the low pressure headers through the bypass for a long period, in one plant, several months, before the turbine is installed. In one of the new topping plants, a condition recently arose under which the entire plant, low-pressure as well as high-pressure, would have had to shut down if the bypass equipment had not been able to replace the topping turbine. These and other operating conditions have materially influenced the design of all the pressure reducing and desuperheating equipment described above, to the end that it will not only operate for the purposes originally intended but also will function under the extremely trying conditions of preliminary plant operation.[3]

[3]Part II describing some of the modern control refinements will appear in the May issue.

Air Conditioning Architecture

AIR CONDITIONING is so new that there has been little opportunity for architects to evolve designs which takes full advantage of opportunities presented. For this reason the service building being built by the Detroit Edison Co. incorporating complete air conditioning is of unusual interest.

Air conditioning and adequate artificial light make it possible to utilize the full building area and increase the available floor area by eliminating light wells.

Ground area is 248 by 120 ft. and the building will be six stories in height. Incorporating the usual light wells in the design would have given a gross floor area of 24 per cent less and the perimeter 38 per cent greater than the building to be constructed. Present ratio of 40 sq. ft. of gross floor area to one square foot of perimeter would have been cut to 22.

Exterior walls will be of glass brick which is not appreciably more expensive than double windows and should have a considerably lower maintenance. Winter heat loss through glass brick appears to be about equal to that of double sash windows and infiltration should be negligible. Summer heat gain is said to be only about half of that through an unshaded factory type sash, although the area of glass brick is perhaps 30 per cent greater than it would be for windows. The brick will not be shaded by awnings, whereas this would have been necessary with windows.

Lighting

The refractive pattern of glass brick picks up all external light regardless of the direction from which it comes and whether or not louver blinds or other glare-dimming devices must be added later has not been determined. Specifications call for shadowless and glareless lights with a minimum level of 35 ft. candles. Ordinary indirect lighting would have required an excessive floor height so that the coffer lighting system has been installed giving a net floor height from floor to ceiling of 9 ft. 6 in. There are nine coffers per bay, each being 4 ft. square and 16 in. deep and containing a 300 watt incandescent lamp with a silvered bowl. The total wattage is 2700 per bay of 600 sq. ft., giving an average of 4.5 watts per sq. ft.

Heating and cooling have been combined in one system performed with a central fan. The general scheme is to recirculate a constant volume of air and to vary its temperature by thermostatic control so as to maintain the desired room temperature. This is accomplished by using two sources of air, one above and one below the room temperature, automatically proportioning the quantities to give the desired temperature.

Air

Air is introduced through sections of the ceiling at low velocity. The ceiling is covered with an acoustic material beneath which are perforated steel plates through which the air supply enters the room. Air is withdrawn from the inner row of bays either to the corridor or directly to the vertical return shafts. From the outside bays it is withdrawn principally through a slot at the sill of the glass brick panel with a secondary withdrawal near the floor to prevent the pocketing of cool air. The sill slot is expected to absorb the down draft created by the glass brick in winter. The ceiling space is an exhaust chamber into which the air from the outside wall of the floor above finds its way. This space communicates with the return shafts through a duct in the corridor ceiling.

It is of interest to note that the backing tile in the exterior walls and much of the inside partitioning in the building will be constructed of a block developed by the company and made from fly ash collected from pulverized fuel fired boilers. This ash is combined with lime and a little rosin and makes a serviceable, well finished structural unit resembling concrete.

The calculated refrigeration load of 465 t. is divided approximately 27 per cent for heat entering the building; 26 per cent for lights; 28 per cent heat from the incoming outside air; 13 per cent from occupants and 6 per cent from fan power. This load depends more or less upon arbitrary assumption as to how much the installed lighting wattage of 981 kw. would be used at the time of maximum load. This was finally assumed to be 40 per cent of the total in the inner bays and none in the outer bays; some of the peak load is expected to occur on bright sunny days.

Coal and Coal Burning

AT THE Fuel Engineering Conference in Kalamazoo, Mich., sponsored by Appalachian Coals, Inc., many papers were presented on coal, its properties and its economical use and from these have been taken the data and discussions which follow.

Combustion Research and Practice

Discussing this subject, L. A. Shipman, combustion engineer of Southern Coal & Coke Co., Knoxville, Tenn., spoke of the need for cooperation between those engaged in seeking the correct principles of coal burning and those engaged in actual burning of coal. It is important that the latter observe what happens in practice and submit the results as a guide and check to those seeking to formulate principles. On the other hand, observation, especially on an underfeed fuel bed, is difficult to interpret unless the observer understands something of what is taking place underneath and the principles involved.

P. Nicholls of the U. S. Bureau of Mines was seemingly the first to analyze coking and non-coking conditions in fuel beds and the importance of caking, matting and coking in fuel bed problems. Considering that ignition of the fuel is heating to a temperature at which it would burn if air were provided, and that the rate of ignition is the rate at which fuel is heated to that temperature, Mr. Nicholls concludes that: 1. When rate of ignition exceeds rate of burning, coking takes place. 2. When these rates are equal, no coking takes place.

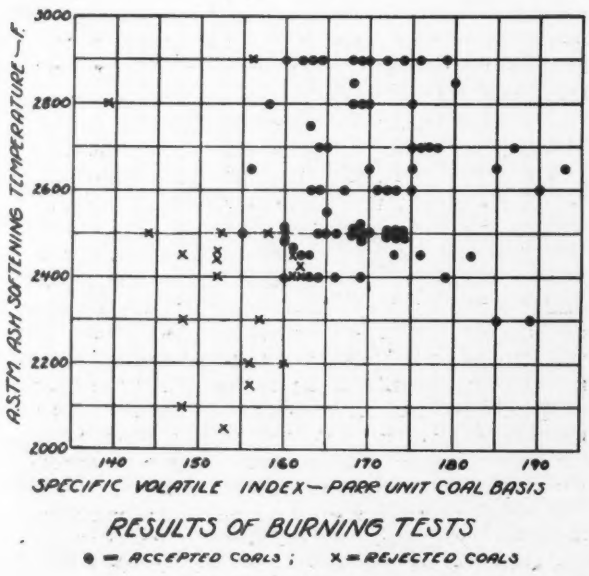


Fig. 1. Tests of ash-softening temperatures

From Carnegie Institute of Technology came conclusions by Juettner and Howard that if liquid products distill as fast as they are formed, no coke results, while W. B. Warren states that rapid heating to 734 deg. F. causes molecules to break down into liquids, while slow heating gives time for molecular decomposition in more stable form, hence yielding more solids. Liquids may decompose into more stable liquids, solids and gases, while formation of coherent coke depends on solvent action of liquids on solid residue for an appreciable time, followed by decomposition of the solution to leave a cementing film between solid particles.

With rapid heating, tars distill before decomposing, hence little cementing film is formed and the coke is not strong. M. A. Mayers has shown the part that air plays as a heat absorber to cool castings and ashes and as a carrier of tar vapors.

To apply these conclusions, consider a hand-fired, clean, open, 5-in., white hot fuel bed, fired light, often and evenly with strongly coking coal. Air passing up

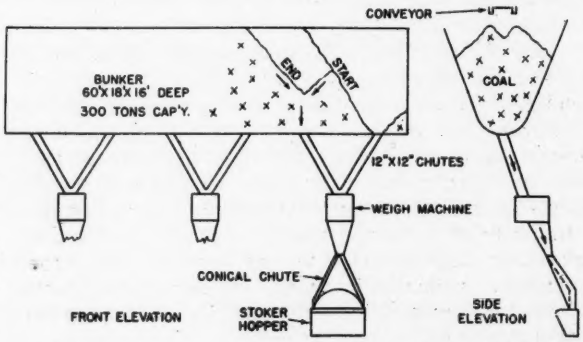


Fig. 2. Coal feeding which caused segregation in the hopper

through the hot coke will cool the grate and ashes, will burn the coke and the excess will carry and burn the tar vapors and volatile gases. The coal will coke but will not be caked or matted together, hence, from Nicholls, "burning rate is equal to ignition rate", the tar does not decompose before distillation and no cementing film is formed. This is for a free burning fire with coking coal.

If one-quarter of this bed is banked down with the same coal, air will be diverted to the thinner section, burning rate is reduced and coking should take place in the banked section because air flow will not carry away heat, and vapor tars will decompose before distilling and solvent liquid will be formed to produce a cementing film.

While the experiments indicate that coal characteristics as regards coking depend upon the manner in which volatile matter is heated and distilled, the matter is complicated because in different coals volatile matter varies in kind and amount and reactions. Also size of particles, rate of temperature rise and oxygen concentration will affect the ignition point and the air distribution, hence the matting effect which causes clinker formation. Furthermore the rate of coal burning is liable to vary in different parts of the bed so that an average rate of 35 lb. per sq. ft. per hr. may actually be 85 lb. at some points and 5 lb. at others, causing localized clinker formation. More knowledge is needed as to coal segregation and *why* coals are suited to certain burning conditions and not to others. Research workers need

more information as to actual behavior of coals in burning and this can best be obtained from the men in the plants.

Coal on Underfed Stokers

With regard to the effect of coal characteristics on the performance of coal on underfeed stokers, A. W. Thorsen of Detroit Edison Co. listed the properties to be considered as: Moisture, ash, heating value, volatile content, coking properties, size and rate of burning.

Moisture displaces useful weight yet must be paid for. To evaporate and superheat it wastes heat at about one per cent for each 10 per cent of moisture, and too much may cause clogging in spouts and hoppers so that distribution may be impaired and some retorts burned. Some moisture is, however, beneficial since moist coal offers less resistance to air flow than dry coal, and reduces tendency to produce smoke. The desirable amount is 3 to 6 per cent.

Ash also displaces heating value and lowers efficiency about one per cent for each 3 per cent of ash content. Some ash, about 5 per cent, is needed for protection of stoker iron.

Low ash is even more important for underfeed stokers than for other types on account of the longer time that it remains in the fuel bed.

Clinker formation due to low ash-softening temperature is of more importance than quantity of ash since, for ideal furnace conditions, exit temperature of the flue gases should be below ash-softening temperature. If the latter is low, this cannot be done without using abnormally large furnace and superheater, also tube slagging and clinkering will be increased. As a result of burning tests by Detroit Edison Co., Fig. 1, approximately 2500 deg. F. was adopted as a minimum value for ash-softening temperature. Mixture of coals may result in serious clinkering even though each of the coals will burn satisfactorily when used alone.

Quantity of ash should, therefore, be kept as near 5 per cent as possible, not over 10 per cent, and minimum ash-softening temperature for satisfactory operation should be determined by trial for each plant according to design and combustion rate.

Heating value of the coal determines the combustion rate for a given load and should be specified, the range in stoker operation being restricted by requirements of other properties between 10,500 and 14,500 B.t.u. per lb. as fired or between 12,500 and 15,000 B.t.u. per lb. dry basis.

As to the effect of volatile matter, which is driven off by heating, high volatile generally accompanies low coking and vice-versa, and low tendency to coking calls for but little agitation of the fuel bed and vice-versa. In one plant with six auxiliary pushers and movable extention grates, used for low-volatile slack, a high-volatile coal made smoke until two of the pushers were removed. The amount of volatile is not an index of smoke-making tendency and stoker design may require alteration to provide for change from a 14 per cent volatile coal to one of 50 per cent volatile.

Coking coals when heated, swell and emit tar compounds that bubble through the coal before gasification, cementing the coal into coke masses which must be broken up to burn readily. Caking coals emit tar when heated but do not swell or form coke masses. Free-burning coals neither cake nor coke but burn to ash in the original shape.

Division between these classes is rather indefinite, caking depending on the size of pieces and rate of burning, the finer coals having a stronger caking tendency. A caking coal may be free burning if combustion rate is so high that the tar is burned as fast as emitted; the fuel bed may not hold together and pieces of coke may be blown into the ashpit. Coals for underfeed stokers should be caking to some extent, to prevent such action, but not too much caking.

One plant having multiple retort stokers in refractory furnaces, with two auxiliary pushers and air control by hand-operated dampers, formed a fuel bed of coking coal so thick that most of the air passed through the side wall tuyeres, giving a thin fire near the walls and heavy fire in the center. By using a moderate caking coal, the trouble was cleared up; the coking coal was satisfactorily burned on a stoker with zoned air control.

On a link-grate type of underfeed stoker, coking coal burned well at moderate load but, at low load, lanes of coke formed from the retorts, were not broken up by the overfeed section and continued to the ash pit with considerable fuel loss and some exposure of stoker iron between lanes. With a slightly caking coal, the coke lanes were broken up at all loads.

A single-retort stoker with no secondary ram burned highly coking 2-in. nut slack badly, forming in the retort a block of coke which failed to burn and resulted in high ash pit loss. Free-burning coal gave satisfactory operation.

While sizing, other than control of maximum size, has received too little attention in the power plant, Nicholls found that maximum burning rate is increased by reducing the size of pieces, while operation at low loads may be improved by increasing the size of pieces. Attempt to burn slack, of from ½ in. to dust, may cause an acute problem of air distribution which can, however, be solved by proper supervision.

Rate at which coal can be burned is governed by maximum burning rate of the coal itself, by ash fusion and by emission of smoke and fly ash. Hence the most economical coal may not be usable in a given plant because maximum allowable burning rate will not permit carrying the load. It then becomes a question of using a less economical coal, changing the furnace design or installing more boiler capacity. Relative economies must then be estimated, since the ultimate aim is to get best over all economy.

Coal Segregation in Bunkers

On this subject, E. R. Kaiser and R. A. Sherman, fuel engineers of Battelle Memorial Inst., Columbus, Ohio, reëmphasized that coarse coal offers less resistance to air flow than small; that the smaller coal, often with high ash content and low ash-softening temperature, has greater clinker forming tendency; that, except for strongly caking varieties, coarse coal produces a weak porous coke that permits comparatively free passage of air; that coarse coal burns readily, because of more air and lower bulk density, hence allows a lower feeding rate by volume; that these features, especially a large percentage of wet fine coal, may limit the maximum steam output, which will, therefore, vary with screen analysis because of difference in heat value.

Variation in size may not adversely affect operation because, for highly plastic coals or with low ash-softening temperature, caking may be about as bad for large sizes

(Continued on page 249)

MODERN UTILITY

II—Planning for, and Carrying out of, a Program To Provide Adequate Generating Facilities on the Extensive Integrated AMERICAN GAS AND ELECTRIC COMPANY SYSTEM

By
Philip Sporn
Vice President & Chief Engineer
American Gas & Electric Service Co.
New York, N. Y.

LITERALLY DEFINED, adequacy of generating facilities means sufficient equipment and personnel to serve all existing consumers, and, any new load that may reasonably be expected, economically, with a proper margin of safety and with proper quality of service. That same definition applies equally well to transmission and distribution facilities. In the case of generating capacity, however, it is necessary to observe that the planning is all pointed toward meeting a load which is generally maximum for only one hour in the year and that if capacity is sufficient to meet that load at that time, plus a sufficient reserve, generating facilities are adequate.

Thus, for example, on systems which depend for the main on hydro-electric plant capacity there may occur a shortage in what might be called primary capacity perhaps once in 8 yr. During the annual peak hour, or, in the case last cited, during that period occurring once in 8 yr., it is without doubt economical to call upon any capacity that might be available, practically without regard to the unit cost or the kind and condition of equipment utilized to provide that capacity.

Implications of adequacy of facilities and adequacy of generating facilities are more complex and far-reaching than might be surmised from the definition given just above. The reason for that is that the facilities involved in giving electric service are expensive in comparison to the gross revenue obtainable through the use of such facilities. For every dollar of gross revenue it takes anywhere from five to seven dollars of capital expenditure for capital facilities. Of this total cost the cost of generation and transmission facilities (and properly considered transmission has to be taken into account whenever generation is considered, because, by and large, an unsound generation picture will be set up if the cost of transmission necessary to bring this generation to the point of use is not properly taken into account) represents a major part, ranging from 25 to 50 per cent of the cost of all facilities.

As a consequence, fixed charges, that is, interest on investment, depreciation charges, taxes and insurance on the equipment and necessary whenever an investment is made to render electric service, represents by far the predominating items in the cost of rendering electric service. In other words, in the general field of electric service, which incorporates the necessary generating facilities, one is confronted with the difficult problem of

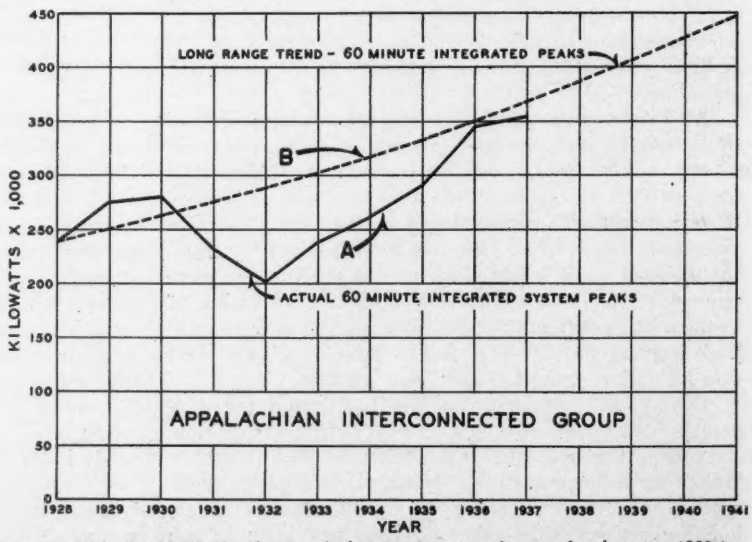


Fig. 1. Actual annual peaks for the Appalachian interconnected group for the years 1928 to 1937, inclusive, and the long-range trend curve of peaks for the years 1928 to 1941, inclusive

STATIONS

Part I. For a quarter of a century, plants of the American Gas & Electric Co. have been prominent among the milestones which mark the progress of the industry from a modest beginning in Edison's historic Pearl Street Station. Progressive policies have kept the company among the leaders not only in power generation but in transmission, distribution and the myriad services rendered by the modern utility. Not the least important of these has been a long and varied experience in interconnections and coordinated system operation. This has resulted in an extensive integrated system which, in itself, stretches from Virginia to northwestern Indiana and southwestern Michigan, and, through interconnections with other systems, becomes part of a transmission network covering the major portion of the United States east of the Mississippi.

Balanced development and economical operation of such a system requires careful and prolonged planning. This planning for the system as a whole, and for individual units, is outlined and the details of carrying it out are discussed. The plan involves several hydro and three new steam stations, Logan, Windsor and Twin Branch

a proper balance between facilities just large enough to render normal service and those so large that a substantial percentage remains idle a portion or most of the time and thus penalize consumers, bondholders and owners with fixed charges on these idle facilities.

Further, the burden introduced by having facilities largely in excess of requirements comes about not only by virtue of the extra fixed charges, but by virtue of low load factor at which these facilities have to operate. Again, planning and constructing the facilities too much in advance of requirements means more onerous depreciation burdens since the likelihood of obsolescence catching up with the period when the facilities are for the first time fully usable is much greater.

Besides this there are other serious problems and difficulties to be considered in attacking the problem of providing adequate facilities or in the more limited problem of adequate generating facilities. Among those are the difficulties in predicting the load factor of the equipment over any extended period of time; complications introduced by wide swings in the business cycle; and the necessity, particularly in the case of generation, of fully taking into consideration advantages that might accrue by purchase of requirements, by obtaining the requirements through interconnections, or, by a program of staggered construction with neighboring or interconnected utilities.

To summarize this broad statement of the problem, it appears to be definitely true that an electric utility system with all of its components, its generating system, its transmission system, its distribution system (it was shown earlier how the transmission system is vitally linked to the generation system and the distribution system is, in turn, closely linked with the transmission system) and its loads, is a complex organism and all the elements are closely interrelated. It is not possible to write specific formula of procedure to follow in providing adequate facilities in general, or, adequate generating facilities in particular.

It must be clear, therefore, that the problem of providing adequate generating facilities, difficult as it is in any major electric system set-up, becomes even more involved in the case of an extensive, integrated and fully coordinated interconnected system extending over a large area. Even though a general formula cannot be written, however, it is believed that a description of how the problem is being attacked on one system, that of the American Gas & Electric Co., par-

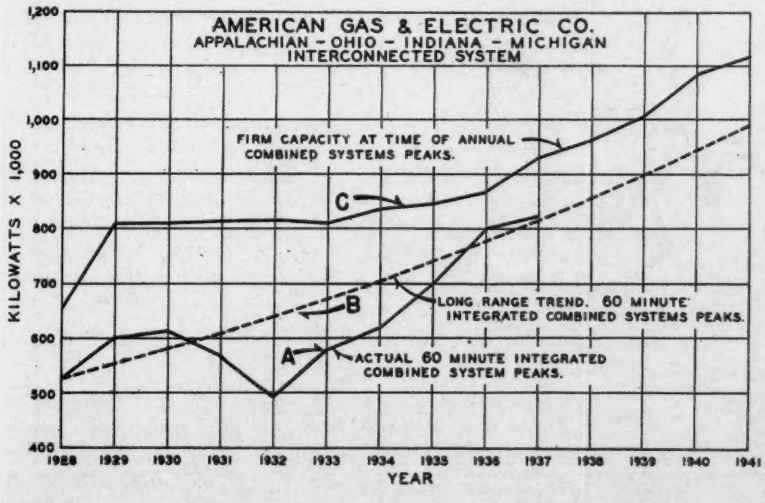


Fig. 2. Actual annual peaks for the American G. & E. Co. Interconnected System for the years 1928 to 1937, inclusive; the long-range trend curve of peaks for the years 1928 to 1941, inclusive and firm capacity for the years 1928 to 1941, inclusive

ticularly on the interconnected system extending over portions of the seven states of Tennessee, Virginia, Kentucky, West Virginia, Ohio, Indiana and Michigan, will be of interest and of possible aid in solving similar problems on other systems of more or less the same type.

II. The Long Term Load Trend

It is obvious that the basis of any expansion of generating facilities is growth, or expected growth, of load. A great deal of study has to be, and has been, given in the case under consideration, to the determination of the loads imposed or to be imposed on the generating facilities. In such consideration it is not possible to overestimate the importance and value of a close contact with, and intimate familiarity of, the history of a company or companies and intimate contact with the immediate and prospective plans of expanion of the major industrial power users. Neither can one overstress the importance of a knowledge of what is being done in the way of load building to increase the consumption of commercial and domestic consumers, nor, the effect on load of extensive rural programs where rural territory is available. All of these are vitally necessary and important, but, in the case of generating facilities, which frequently take from 2 to 3 yr. between the initiation of the project and the completion, it is obvious that something more fundamental is needed. That fundamental knowledge can be summarized in the one item of long range load trend.

As typical of what can be done in that direction, reference is made to Fig. 1. Here two curves, A and B, applying to the Appalachian Electric Power Co. and two of its affiliated companies, Kentucky and West Virginia Power Co., Inc., and Kingsport Utilities, Inc., are shown. These represent the results of a study of loads and generating capacities for the years 1928-1941. An examination of Fig. 1 will show in Curve A a predepression peak, and amounting to some 280,600 kw., occurred in 1930. This, it will be observed, was not equalled or exceeded until 1935. While the 1936 peak was above that, and a peak considerably higher established in 1937, the load as is well known, has receded since 1937 and is now below the 1937 level.

Load Prediction

The long term load trend is represented by Curve B. It will be seen that although for the years 1929-1930 the actual loads are considerably above the long range trend curve, they are considerably below that for the five years 1931-1935, inclusive, and did not come up to the long range trend line until 1936. This brings out the difficulty of making load predictions even for a short period. Nevertheless, it is obvious that something besides immediate load data is needed as a basis of planning generating facilities.

In the case of the group under discussion that is supplied by Curve B, the best "guesstimate" of the probable load growth over a period of time. As a matter of fact, in the case of this particular group it represents a com-

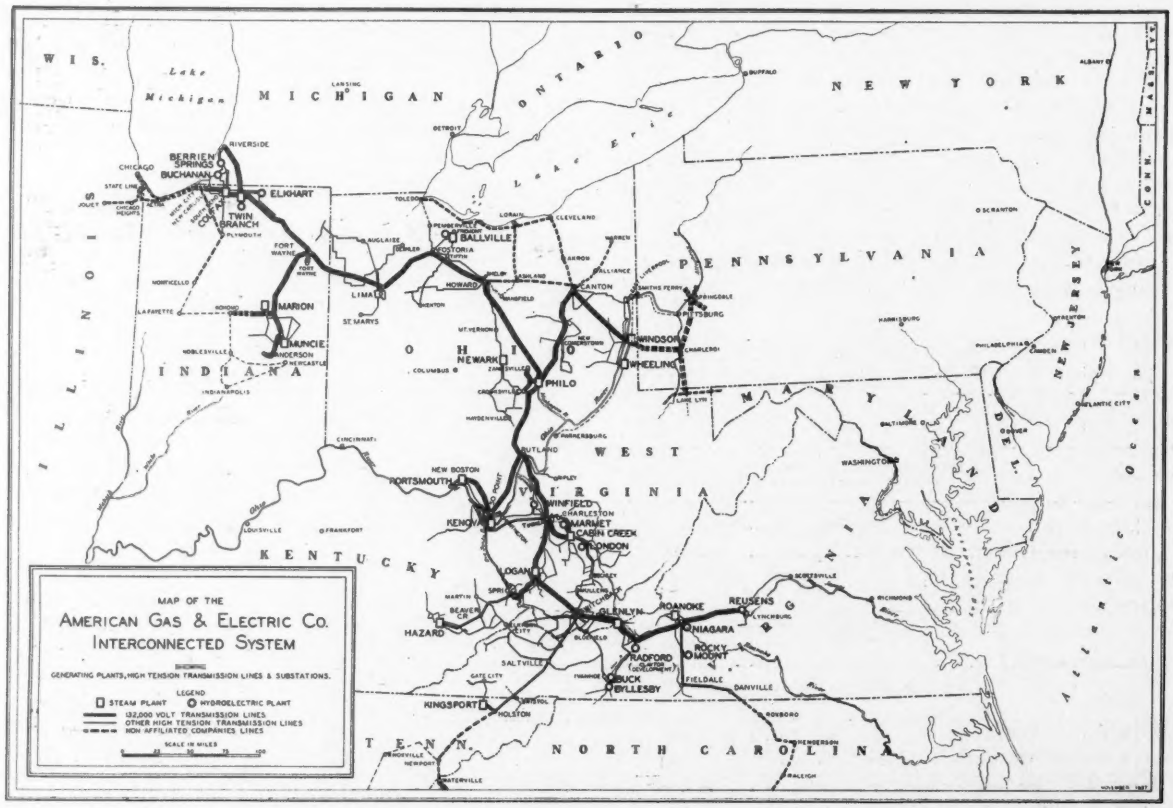


Fig. 3. This American G. & E. integrated and interconnected system serves parts of seven states and had an all-time one-hour peak load of 822,000 kw. in October, 1937. The continued economical balance between transmission and generation is assured in the new generation expansion program for this system by the addition of capacity to existing steam plants (Logan, Windsor and Twin Branch) and by the hydro developments on the Kanawha River and on the New River

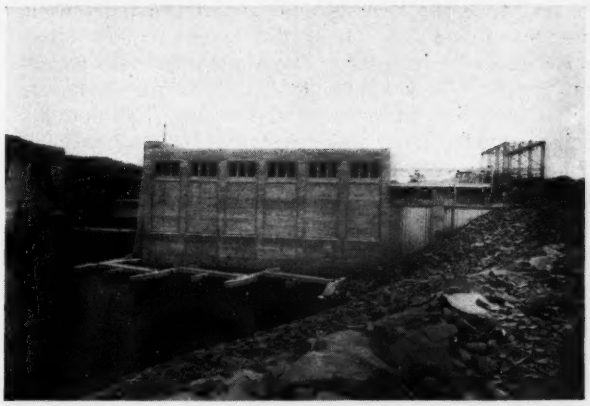


Fig. 4. Winfield is located on the Kanawha River below the London and Marmet Plants and, like them, is built at a government navigation dam under a 50-yr. license from the Federal Power Commission. One I. P. Morris Kaplan and two Newport News automatically adjustable blade runners, having a total capacity of 27,550 hp. are installed. The normal operating head is 26 ft.

pound growth of 5 per cent. Two things, further, are clear from an examination of Curves A and B in Fig. 1. First, that the load trend for any year, for example, 1935-1936, the last year available at the time this study was made, cannot be taken with any safety as an expected trend for any appreciable time. Second, that the load trend for a period even as long as 4 yr., and as represented in the case in Fig. 1 by 1932-1936, is not safe enough as a basis for planning a generation program.

This is obvious from an examination of the extension of the trend lines of the 1935-1936 and the 1932-1936 periods, and a comparison of either with the actual maximum loads reached in 1937, and Curve B which is believed to be the probable long term trend curve. For example, for the period 1941, the 1935-1936 trend line would show a load of some 180,000 kw. and the 1932-1936 trend line of some 75,000 kw., higher than the long term trend. In view of the fact that at present, it appears that the actual load in 1941 will probably be below the long term trend line, there seems to be no justification for raising its slope.

It seems likely, however, that a thorough study of the past history of any individual system, coupled with the knowledge of the plans for growth and for expansion of service on the system, can in every case be made to yield a long term trend line that can be utilized for planning a generation program. That is true, provided one does not attempt to plan too far ahead, and that, in so far as it is possible, checks are continually applied to make sure that the actual growth does not deviate too far from that predicted, or, growth has materially changed from expected trends, proper corrective measures are made in the planning.

III. Description of the A. G. & E. Co. Interconnected System

Figure 3 is a map showing in skeletonized form the location of the principal generating plants, transmission lines and interconnections of one part of the system in question. This portion of the system, as will be observed, serves parts of seven states previously mentioned and is divided into three principal groups: a, the Appalachian group, in which are the two affiliated companies, Kentucky and West Virginia Power Co., Inc., serving the section of Kentucky indicated, and, Kingsport Utilities, Inc., serving the area in and around Kingsport, Tenn.; b, The Ohio Power Co., with which is the affiliated Wheeling Electric Co. serving the territory in and around Wheeling; and c, a group composed of the Indiana & Michigan Electric Co. and the Indiana General Service Co. serving the northeastern and central section of Indiana and a portion of southwestern Michigan. This entire integrated group is interesting from the standpoint, that, although it serves only about 2 per cent of the total population of the United States, it generates about 4 per cent of the total electrical energy generated in the nation. This is accounted for primarily by the existence of heavy industrials, particularly steel, chemical, coal and related industries, well distributed over the area. Most of those, of any consequence within the area, are served by one or another of the companies in question.

Principal generating plants starting from west to east are located in Twin Branch, Indiana; Philo, Ohio; Windsor, West Virginia; Kenova, West Virginia;

Table I. Summary of Existing and New Equipment at Logan, W. Va. Steam Plant. For tabulation of principal data on this station see Power Plant Engineering, p. 721, December 1937.

EXISTING PLANT	PLANT EXTENSION
BOILER PLANT	
3—B. & W. 1964 hp. (approximately 200,000 lb. hr. each) with B. & W. chain grate stokers. Each boiler is equipped with induced and forced draft fans. No economizers or air heaters. Steam pressure 250 lb. gage — Total Temperature 600 deg. F.	1—Combustion Engineering Co. 1,000,000 lb./hr. dry bottom steam generator with economizers and Ljungstrom air heaters. Boiler is fired by a pulverized coal unit system consisting of 4 Hardinge mills each having a capacity of 15 tons per hour. There are 2 Sturtevant motor driven F.D. fans and 2 Sturtevant turbine driven I.D. fans. Boiler operates at 1325 lb. and 925 deg. F.
TURBINE PLANT	
2—G.E. 18,000 kw. — 1800 r.p.m. units with surface condensers and bled at 3rd stage for feedwater heating. 2—G.E. 4800 kw. — 3600 r.p.m. units with surface condensers. 1—G.E. 4800 kw. — 3600 r.p.m. condensing unit (at another location).	1—G.E. 40,000 kw. 11 stage 3600 r.p.m. superposition unit with hydrogen cooled generator; exhausts at 200 lb. into the existing low pressure plant. (2—18,000 kw. and 3—4800 kw. [revamped] low pressure turbines.)
CAPACITY	
45,600 kw.	44,800 kw. (includes 4800 kw. unit moved to Logan from another location). Total plant capacity 90,400 kw.
FEED HEAT CYCLE	
	Feedwater is heated to a final temperature of 383 deg. F. with steam bled from the 1st and 3rd stages of the low pressure 18,000 kw. units, with exhaust steam from the turbine driven auxiliaries and with 200 lb. steam from the high pressure turbine exhaust. In addition to the necessary heaters a deaerating heater (Elliott) and an evaporator (Griscom-Russell) was added to the cycle. Three boiler feed pumps (two turbine driven — one motor driven) and one turbine driven pump are Ingersoll-Rand and the other turbine driven pump is Foster-Wheeler.
POWER TRANSFORMERS	
20,000 kv-a. bank—132/44 kv. Existing generators connected to the 44 kv. bus through transformers.	Westinghouse 100,000 kv-a.—4-winding bank 132/44/11/4 kv. (replace the 20,000 kv-a. bank). 44 kv. winding connects to existing 44 kv.

Cabin Creek, West Virginia; Logan, West Virginia and Glenlyn, Virginia. A small group of hydro plants operate in northern Indiana, southern Michigan, southern Virginia and on the Kanawha River around Charleston, W. Va. The system, however, is predominantly steam, at present about 87.5 per cent in terms of installed capacity, or, 90.5 per cent in terms of kilowatt-hour output in an average hydro year.

An examination of Fig. 3 discloses two other significant features, First, that the generating plants are scattered quite regular over the entire system but are tied together by an extensive transmission network. This is a heavy 132,000 v. grid, double circuit for practically the entire distance and consisting of some 1,390 physical miles of transmission lines and about 2,500 circuit miles. This transmission network serves the double purpose of feeding the load centers and tying together, so as to take maximum advantage of such coordination, the various generating plants.

As the result of many years of definite planning, no large scale long distance transmission of power is involved, however, because: long distance transmission is uneconomical; maximum service reliability is not promoted by such transmission; and, in many cases mouth of mine plants could be located for important load centers.

Second of the outstanding features shown by Fig. 3 is the extensive interconnections with outside systems. An examination of the map will show an interconnection at the Virginia-Carolina border, an interconnection at Kingsport with the Tennessee Public Service and north of Kingsport with the Eastern Tennessee Power and Light Co. In the northern part of the system are interconnections with the West Penn Power Co., Monongahela-West Penn Public Service Co., The Ohio Edison Co., The Toledo Edison Co., The Ohio Public Service Co., the Northern Indiana Public Service Co., Northern Indiana Power Co., and numerous others.

In most of those cases interconnections have been in existence for periods of from 5 to 20 yr. In the course of that time the benefits and advantages inherent in interconnection have been developed and explored, sometimes on a long term, sometimes on a more temporary, basis. They are being further explored as the art of operating interconnected develops. This not only helps provide economical primary generating capacity but yields numerous other benefits, the net effect of which is to decrease the cost of electric service by decreasing the cost of generating or transmission facilities, improving service, or both. The point definitely needs to be kept in mind that the existence of such interconnections on an extensive system of the type under discussion is a vital factor and has to be given major consideration in any study intended to serve as a basis for providing adequate facilities and in laying down a program for the construction, or, otherwise obtaining necessary generation or supply facilities.

IV. Basis of Procedure on the A. G. & E. Interconnected System

The general basis of procedure on the interconnected system described has been to bring about an adequacy of generating facilities for each principal group within the coordinated system, that is, to make each group self-sustaining. This is sound from an engineering economic viewpoint because of the long distances involved and the unsound economics of long distance transmission of power, and has the further advantage of simplifying considerably intercompany relationships. Keeping in mind the broad objectives of such a program, it is fully realized that over short periods of time it may be highly desirable to transmit power either in one direction or another, just as long as the amounts involved are not beyond the capacities of the existing transmission network nor do not disturb its major function as an integrating and coordinating medium. The net effect of such a program is to bring about the equivalent of staggered construction between companies in the group. As a matter of fact, the idea

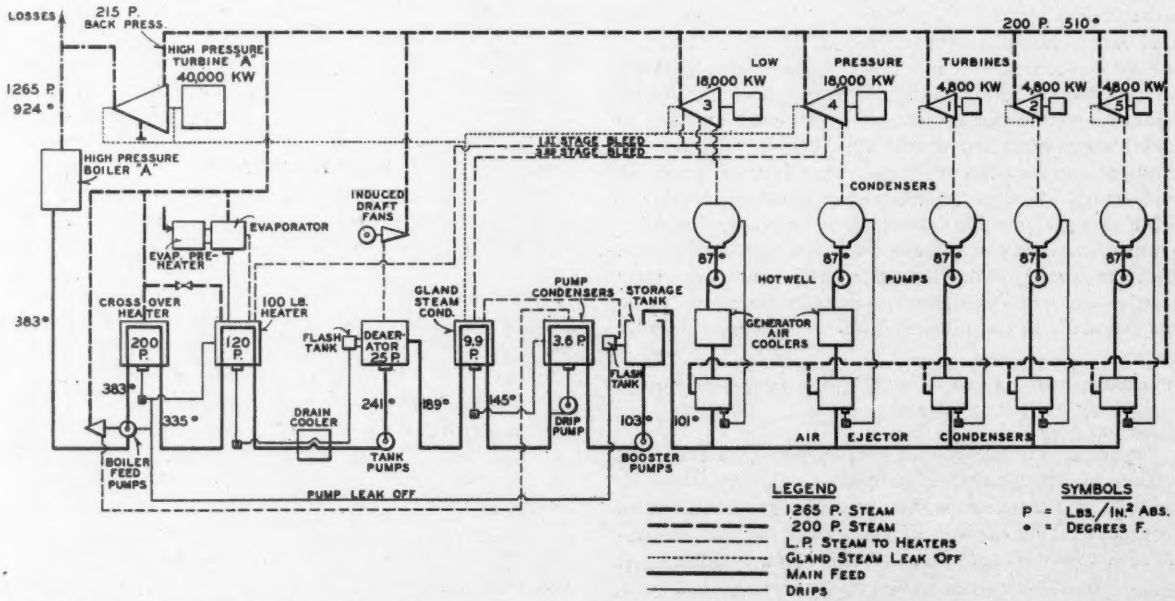


Fig. 5. Heat flow diagram for the Logan Plant. The superposed unit cuts the station heat rate from about 23,000 to 12,000 B.t.u. per kw-hr.

of staggering construction has actually been extended where possible to outside groups and at the present time one in the group is actually obtaining a block of its capacity from an outside company. That is the Indiana & Michigan Electric Co. which is buying a block of power from the Northern Indiana Public Service Co.

Within the broad framework of aims outlined above, a careful study of actual loads and long term trends was made not only for each of the individual companies (the results of such a study in the case of the Appalachian group have already been shown in Fig. 1) but a similar study was also made for the entire integrated system. This is shown in Fig. 2. Here Curve A represents the actual load experienced over the periods 1928-1937 and Curve B represents the long term trend. It was realized that following a long term trend as a guide in laying down a capacity program might, in a period of unexpected expansion of load, result in the necessity of operating secondary or standby plants for peak purposes. The economics of doing that are so sound, however, that it was definitely figured as part of the generation program, in fact, it was hoped that this would be the case.

It is curious that the place of the secondary or standby plant in the picture of rational power generation is frequently not fully appreciated. Thus, at annual load factors of 10 per cent or less, the secondary plant having a production cost of from 1 to 2 cts. per kw-hr. will still be much more economical and may represent only one-half of the cost of energy obtained from a modern plant, when the fixed charges on the new investment are taken into consideration.

An important keystone in the arch representing the generating program adopted on the interconnected systems is the necessity of maintaining proper relationship between the cost of transmission and the cost of generating facilities. Previous studies, made over periods of time going back more than 10 yr. and restudied and elaborated within the last several years, had shown that the existing transmission system represented in Fig. 3 was adequate for an increase in load up to almost double its present capacity, provided the generation is properly distributed. Fortunately, on the American Gas & Electric Co. system such distribution is possible owing to the location of adequate sites from a standpoint of water and coal supply.

That basic plan, therefore, is being followed and increments of capacity are being made at various existing plant sites throughout the system. The effect of this is not only to make necessary a minimum expenditure in the way of transmission facilities, but to make more economical increments of capacity, bring the generation closer to the center of load and make each area self-sustaining. This latter minimizes the possibilities of a major interruption or catastrophe in one part, seriously affecting another, and possibly remote, portion of the system by virtue of a general breakdown of the balance between generation and load in one particular area.

Any other plan, one involving for example the development of new plant sites even though it might have made possible more modern plants, would have meant heavier initial expenditures on the so-called framework of a power plant, such as railroad sidings,

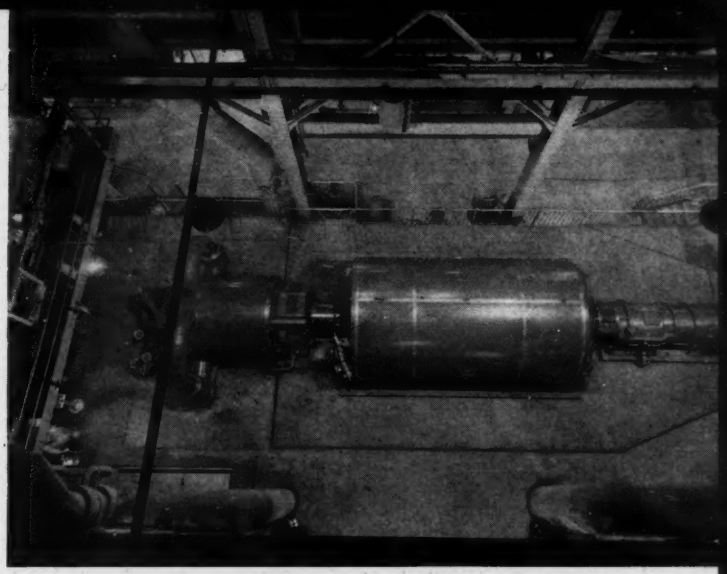


Fig. 6. The new Logan superimposed 40,000 kw. turbo-generator occupies the space made available by the removal of three old low-pressure boilers. Compare the overall length of the high-pressure turbine with the overall length of the exciters and reducing gears

intake and discharge tunnels, apparatus shops, flood protective works, etc. It would also have meant much heavier expenditures for transmission and corrective equipment with the concomitant raising of the cost, and lowering of the grade, of service rendered.

In order to put into more concrete form illustrations of the working out of the principles discussed, there will be described below the programs of generation set up or being carried out on each of the three major groups of integrated system under discussion.

V. Generation Program on Appalachian System

The program of expansion on the Appalachian Electric Power Co. system to provide adequate generation facilities for its own load and for the load of those of its affiliates which it serves, has during the last 5 yr. consisted of; building of the London, Marmet and Winfield hydroelectric plants of the Kanawha Valley Power Co., the entire output of which is taken by the Appalachian Electric Power Co.; reconstruction and expansion of the Logan steam plant; and, the beginning of the Claytor hydroelectric plant.

London and Marmet developments have been previously described[1]. These two plants have a capacity of 34,500 kw. They are run of river plants developed and constructed by the Kanawha Valley Power Co. under license from the Federal Power Commission. Water is obtained from two dam structures erected by the United States War Department as part of the navigation improvement on the Kanawha River called for in the River and Harbor Act of 1930. The dams and power plants are located almost in the center of the Appalachian system. Thus, although the ecenomics of hydro is in general very tenuous, it was possible by careful design and by the fact that almost no transmission had to be provided to absorb the output of these plants, to have a set-up such that the cost of power would not exceed that obtained from equivalent steam generating stations. The details of design and the methods of carrying out the project on the first of these two dams have already been previously described in this journal. The method of taking care of the same fundamental requirements on the third of these plants, Winfield,

[1]See Power Plant Engineering, February, 1937, page 70.

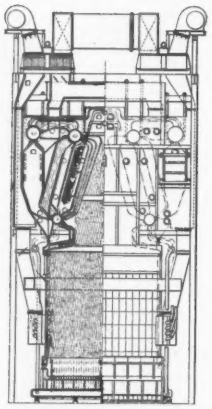


Fig. 6A. Cross section of the Logan 1,000,000 lb. per hr. boiler

will be covered in a subsequent issue. The Winfield plant has a capacity of 22,000 kw. and a view from the downstream side is shown by Fig. 4.

In addition to Logan, the principal steam plants of the Appalachian Electric Power Co., are located at Glenlyn, Kenova and Cabin Creek. The location of these with reference to the system as a whole and with respect to the other affiliated groups can be seen by referring to Fig. 3. The broad study of system development already outlined has shown consistently that additional capacity, except for such hydro capacity as has already been mentioned, could best be added by extending the present plants. When it became evident toward the end of 1935 that additional capacity would be needed to meet the expected loads during 1937, studies were confined to determining whether this capacity should be provided by the extension of existing plants or by purchase. The final decision was to proceed with an extension of Logan.

Logan was picked because: it was the least efficient of the four major plants on the Appalachian system; it is excellently located with reference to the load center and interconnected transmission facilities; it involved the least building changes and the least rebuilding of electrical layout; superposition offered an economic block of power which seemed to assure that for several decades to come it would complete the station from a capacity standpoint since for the present the limit of condensing capacity had been reached; and the extension not only gave the most economical increment of capacity, but, because of the favorable fuel situation, was justified whether the increased capacity was utilized for new load or for load displaced from one of the other stations.

A summary of this addition at Logan[2] with regard to boiler plant, turbine plant and total generating capacity before and after plant extension, is given in Table I. As will be seen, the outstanding feature in connection with the boiler is the fact that it is a single, 1,000,000 lb. per hr. unit, operating at a pressure of 11,325 lb. per sq. in. and at a temperature of 925 deg. F. Selection of steam conditions and equipment was influenced by: first, space limitations in the existing building, need for the maximum economical increment of capacity, limited low pressure capacity which called for the maximum ratio of high to low pressure capacity and capital cost economies made possible by a large unit; second, the belief and conviction that past operating experience assured adequate availability of a carefully and properly engineered unit of that size; the thermodynamic performance, without the complication of reheat, made possible by 925 deg. F. and the conviction that this temperature was just below the temperature limit of safe operation with metals known and economically feasible at present. The dry bottom design was influenced primarily by the wide range of coal ash fusing temperature expected to be handled and by a wide load range of up to 5 to 1 over which the unit was expected to operate.

The cycle chosen is shown diagrammatically in Fig. 5. The outstanding features here are: extreme simplicity of flow; use of turbine drive for induced draft fan and boiler feed pump drive at cross-over pressure; omission of high pressure heaters and the placing of the boiler feed pumps beyond the last heater. Here the considerations were, respectively, economy of piping, ease of control and capital cost economies that turbine drive made possible, capital economies greater than operating savings that the omission of high pressure heaters brought about, and capital economies in heater costs. No resultant drawbacks were expected from the use of high suction temperature on boiler feed pumps, because experience had shown that pump difficulties were not so much a function of suction temperature as of suction temperature variation. Adoption of the cycle indicated was expected to reduce an existing B.t.u. performance from around 23,000 to approximately 12,000. While the plant has not been on long enough to give final results, some six weeks operation has actually indicated that it will be within 200 B.t.u. of the expected performance.

On the turbine and alternator end, Logan represented the largest 3600 r.p.m. turbine at the time the order was placed. The turbine is an 11-stage unit of the now well-known double-jacketed construction in which exhaust steam, at approximately 200 lb. in this

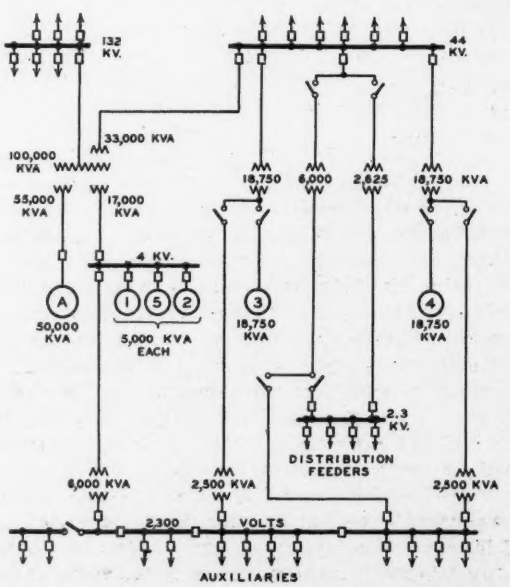


Fig. 7. The output of the station is taken by one new Westinghouse 100,000 kv-a. 4-winding transformer bank. The plant normally takes care of the local load and the load supplied to the Logan District by the 44 kv. system and the remainder of the output is supplied to the 132 kv. system

[2]For a tabulation of the principal data on Logan, Tundra and Twin Branch see Power Plant Engineering, page 721, Dec. 1937.

case, surrounds the inner casing so that the outer casing is subject only to a pressure between that and atmosphere. Although the unit provides for bleeding at the seventh stage, this has, for reasons already described, not been made use of. The background of experience obtained at the Deepwater (N. J.) Plant with 3600 r.p.m. units of approximately 40 per cent the size of the Logan unit gave definite grounds for concluding that this design, as modified by the double-jacketed construction, would give a safe unit at that high rating.

On the alternator end the outstanding features are hydrogen cooling of the rotor and stator end windings and water pad cooling of the balance of the stator. Heat is abstracted from the stator iron and copper by inter-leaved water cooling pads through which water circulates in a closed system. Excitation, not only for the high pressure unit but for the five low pressure units, is provided by a geared 1800 r.p.m. triple armature set. One of these armatures provides excitation for the high pressure unit, the other for the five low pressure machines, while the third acts as a common sub-exciter. The alternator was designed for hydrogen operation up to 15 lb. per sq. in. but has operated most of the time at a pressure of approximately 0.5 lb. per sq. in. A view of the completed unit in operation is shown in Fig. 6.

The electrical layout to take the output of this machine, as well as the revamped low pressure machines, out to the high tension system, is shown in Fig. 7. Here it will be noticed that a single, Westinghouse, four-winding bank contains a winding which gives an outlet for the high pressure turbine; another winding to which the three 5000 kv-a. machines are connected at 4000 v.; a third winding which acts as a tie to an existing 44,000 v. bus to which the two larger low pressure units are connected; and, finally, a 100,000 kv-a. gathering winding which takes the entire output to the 132 kv. bus. The method of providing station auxiliaries of adequate reliability is clearly indicated in the diagram. This unit went on the line about December 1, 1937, and while minor adjustments are still being made, it is expected that it will be available to take full load on a firm commercial basis within the month.

Claytor Hydro-development

The final block of capacity on the Appalachian system covering the present program will be provided by the Claytor development located on the New River near Radford, Va. This will consist of approximately 75,000 kw. of capacity in the form of four Francis turbines, each operating on a normal head of 110 to 112 ft. A considerable storage area of approximately 100,000 a. ft. is available so that although the average annual output will be only of the order of 204,000,000 kw-hr. (with a variation from extreme dry to extreme wet year of from 140,000,000 to 400,000,000 kw-hr.) it will be possible by the use of the storage for draw-down purposes to get the full capacity of the station during peak periods. Further, the limited amount of hydro capacity now available on the Appalachian system will make possible an excellent balance between steam and hydro capacity and the maximum utilization of the latter and the most economical utilization of the former facilities.

It is expected that the Claytor plant will be ready for commercial operation about January 1939. Thus, the completion of this project, it is expected, will place this group in a position of having full and adequate generating facilities probably up to the year 1941, although obviously, an acceleration of the trend of industrial expansion may alter that. In any event, it is expected that with the completion of this program, the capacity situation will be such that adequate planning and economical and unhurried construction will be possible if further additions to facilities should be needed.

Editor's Note: Part II—Covering the Ohio Power Co. system with Windsor Station and the Indiana & Michigan Electric System with Twin Branch Station will appear in the May issue.

Coal and Coal Burning

(Continued from page 241)

as for small. For medium caking, however, size is important, and segregation in the bunker from injudicious handling such as falling on a conical pile from chute or belt conveyor when filling the bunker, will result in fines in the center and coarse particles around the edges, with consequent variation in density, heat value and moisture that may cause trouble in burning.

For a plant where coal was carried to the bunker by a belt conveyor, thence discharged through chutes from the center line of the bunker to a weigh machine and then through a conical chute to the stoker hopper, Fig. 2, tests were made of the coal delivered to left, center and right thirds of the hopper by taking adequate samples every 20 min. over an 11-hr. period. Tendency would be for fines to collect near the center line of the bunker, hence be fed first to the stokers, coarser aggregate from near the sides of the bunker flowing in as the center of the pile was lowered. Coal feed to hoppers and to stokers conformed to good usual practice. Coal was coking type with ash-softening temperature of 2600 deg. F.

With the chute to the weigh machine feeding from the right, coal in the left third of the hopper was distinctly smaller than in center or right thirds, the two latter being about equal. Test of ash content showed that the larger the size of pieces the greater that content, also that it varied considerably, while being quite uniform for smaller sizes, 0 to ⅜ in. At first, coal came from the center of the pile in the bunker and was largely small size. Later, as coal came from the sides of the pile it was larger. Variation of its ash content might well be due to inclusion of a single large lump of high ash content in some of the samples. Observation of the fire through side doors showed no change in nature of the burning due to change in size of coal.

Conclusions from the test were: That segregation in the bunker with typical design and handling will cause wide variation in size distribution over a period of hours; that this may cause considerable variation in ash content, especially if there is variation in particle density, since heavy particles will tend to go with the fines; that a large number of samples must be taken frequently to get true results; that even for coal carefully loaded in cars to prevent segregation, coal may segregate in the bunker to nullify this care; that, although no serious effect on burning was found in this case, such effects might readily appear in the case of a weakly-caking coal with low ash-fusion temperature and high ash concentration in small particles, when burned at high combustion rates.

Check the Diesel Crankshaft

Ninety-five times out of a hundred shaft failure is the result of lax operation and maintenance. Chiropractic treatment is effective on the backbone of the engine.

By ELTON STERRETT

FREQUENTLY various Diesel parts are compared to certain organs of the human body and the crankshaft may be likened to the backbone, without which transmission of motion is impossible. Bulking large, it is apt to be regarded by the engineer as able to withstand anything. As a result of this and the little thought given to the important duty the shaft performs in transforming reciprocating into rotary motion and transmitting intermittent torque smoothly to the driven machine, upkeep is usually confined to infrequent tightenings of the main bearings and the supervision of oil supply in the engine sump.

On a four-cylinder engine turning up 300 r.p.m., the crankshaft must resist upward of two and one half billion reversals of stress during one working year if only loading directly related to the reciprocating motions of the four pistons in considered. From this it is easy to understand why, if flexure or bending action is present, crankshafts sometimes fail even when transmitting only a fraction of their rated horsepower.

That high tensile steels, metallurgically alloyed to increase their resistance to the destructive effect of alternated bending and straightening, may and frequently do break down on the testing machine at a number of alternations below that withstood by the average slow-speed crankshaft, emphasizes the fact that an engineer's first care of a crankshaft should be to insure that the center of rotation for all main bearings lie in one straight line.

Use the Tram

A preliminary check should show the crankshaft free of all restraint at the outboard bearing beyond the flywheel if one is provided. If the short stub of shaft carrying the flywheel is held between two bearings in a line not an exact continuation of the engine main bearings, bending must take place at one side or the other of the main bearing nearest the flywheel. From the angle of plant and personnel danger this is the most hazardous point for stress concentration.

Diesel builders frequently furnish a tram or shaft checking pin with their engines, this being used by placing one end in registry or contact with some fixed point within the case and the other just touching the shaft alongside or through the oil lead to the main bearing. This tram or pin gauge is rarely or ever checked by the operator against bearing settings on a new Diesel so after some thousands of hours of operation, the engineer has no comparative data upon which to base the showing made by testing clearance with the pin. Unless taken on the various bearings with the shaft revolved at each reading to maintain the same relation of crank throws and rod angles, the check is not close enough to indicate a degree of misalignment more that ample to develop fractures.

Much more accurate shaft alignment can be secured by the use of a straight-edge and a micrometer than with the tram pin, but whichever method of checking shaft position is adopted, final adjustment should be verified by removing the connecting rods, one at at time, and checking the distance between spots on the adjacent sides of the throws several times during one complete revolution of the shaft. If these two points revolve in planes which are perfectly parallel, the distance X of Fig. 1 will always "mike" the same. If the sections of crankshaft controlling the location of these two sides of the throw are not rotating about a common center line, the distance between the trial spots will vary, the amount of plus or minus reading being an indication of, though not a quantative measurement of, misalignment.

By checking each throw in turn, working preferably from the flywheel end, and adjusting to obtain a close check of parallelism in the throws as outlined, the upper halves of the main bearings can be brought accurately to line. With the upper halves thus satisfactorily adjusted, the lower or normally movable half of the bearing may them be given its final setting by

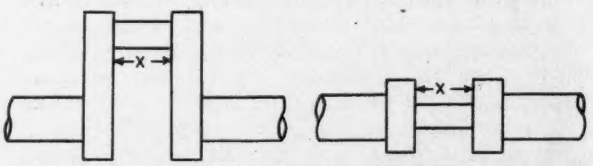


Fig. 1. If the bearings are in line, micrometer measurements of x should be the same as the shaft is rotated through one complete revolution

means of the wedge and screw and at this point to allow the proper clearance between bearing and shaft.

In the absence of any definite recommendation by the engine builder, a safe starting point is to allow 0.001 in. clearance for each inch of shaft diameter at the main bearing. Thus, with a shaft 6 in. in diameter, the trial clearance to allow a main bearing, cold, may be assumed to be 0.006 in. With uniform load on the Diesel, as driving a generator, this clearance may usually be reduced, and on some makes of engines even halved with good results. Any reduction in this amount of clearance, should be carefully watched until it is certain there is no binding or oil restriction.

Usual practice in adjusting a main bearing wedge, however, is not to measure clearance in terms of shaft diameter or fractions of an inch, but to follow some rule-of-thumb scheme involving tightening the bearing to refusal, and then backing off on the adjusting screw one "flat" on its head. Since the various manufacturers do not all use a screw of the same pitch, nor

even adhere to one style of head on the adjusting bolt, following this questionable "rule" may introduce much more clearance than is desired, with resulting noisy operation and greater danger of excessive flexure of the shaft under running load. When to the variations in bolt specifications is added the range in adjusting wedge angles, clearance on two well-known makes of engine will be found to vary from 0.00292 in. in the one case to 0.01117 in. in the other, nearly four times as much on one bearing as on the other. A series of reprsentative values obtained by following this "one flat" method is presented in the accompanying table and some of those frequently applying to industrial Diesels plotted on the chart.

Calculations

Since the lift of the adjusting screw is directly related to the threads per inch on the adjusting screw, it is possible to check threads other than those listed by interpolation. For example, a screw with eight threads per inch gives half as much bearing clearance per flat, bolt heads being the same, as would one having four threads per inch. From this, it is clear that ten threads on the adjusting screw would halve the values per flat obtained with a five-thread bolt.

Exact lift per flat may be computed from the trigonometric formula

$$X = Y \tan A$$

where

X is the amount of lift in units determined by Y.

Y is the amount of travel of the wedge, usually expressed in thousandths of an inch, obtained by turning the screw one flat of the bolt head.

A is the wedge angle and the tangent may be taken from any book of trigonometric functions without computation.

Assuming a wedge with a 6 deg. angle and an adjusting bolt with ten threads to the inch and an octagon head, advancing the wedge one turn of the bolt, or one thread, would move it 0.100 in. As there are eight flats, one flat would give 0.100 divided by 8 or 0.0125 in. as the value of Y or expressing Y in thousandths of an inch 12.5. From the tables, tan A is found and by calculation

$$X = 12.5 \times 0.10510$$
$$X = 1.314 \text{ thousandths of an inch}$$

This is obviously a slight clearance for any but a small shaft of say 2½ in. dia.

End Clearance

End play of a crankshaft will cause the main bearings to wear spool-shaped, tending to reduce the effective bearing surface and increase the loading per square inch with consequent decreased lubrication and greater wear. Again in the absence of definite recommendations by the engine builder, the rule of 0.001 in. clearance per inch of shaft diameter may be followed, but in this case, adjustment and measurement should be made as soon as possible after the engine is shut down, following a run sufficiently long to insure thorough warming up and maximum expansion of all parts. Otherwise the clearance provided will be sufficient only to care for the more rapid expansion of the shaft over the crankcase and engine base. For a 6 in. shaft, a clearance of 0.006 in. at each end adjustment (after centering the shaft in each of the main bearings or dividing the bearing side clearance as evenly as possible if the same feeler does not check this value through all the mains) will take care of end travel of the shaft and result in much quieter operation. If the end play is adjusted at these two points, the original clearance allowed by the engine builder at each main bearing between adjacent crank throws, will be maintained much longer than if the entire shaft be allowed to shift lengthwise at will with each power impulse.

Since, due to piston reactions, a crankshaft tends to wear into the form of a much-rounded three-lobed cam in service, it eventually reaches the point where it is impossible to maintain the desired bearing adjustment and the shaft must either be reground or renewed. Due to the need, already stressed, of keeping the rotating centers of the main bearings in one straight line, it is the exceptional repair shop that is able to undertake this job and turn out a shaft which will give extended service commensurate with the work and expense involved. If wear has been allowed to reach the point where regrinding is indicated, better results will nearly always be secured by returning the shaft to the manufacturer for servicing and the fitting of a new set of bearings at the same time.

The Factory Is Best

Babbitting, in the engine room, of the main bearing halves is another repair job which seldom pays dividends. If labor be charged against the job, new or replacement units may be obtained from the engine builder for little more than the cost of a home-made renewal. There is no comparison between the service and reliability of bearings made under accurately controlled manufacturing processes and those turned out in the power plant. Of course, emergency repairs must

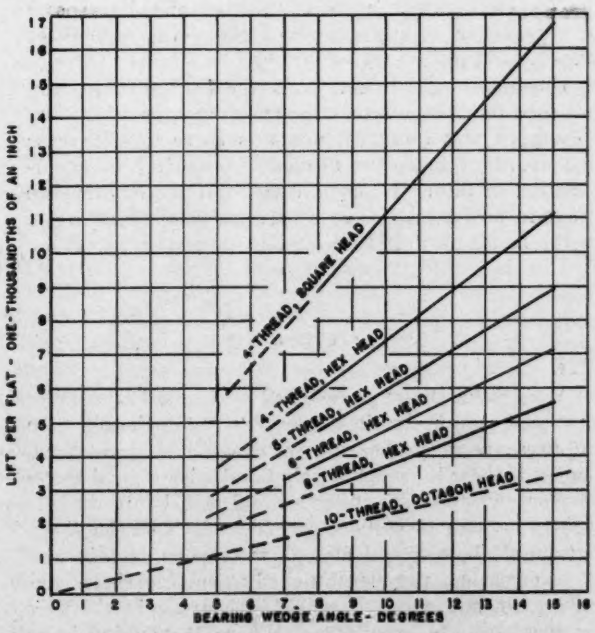


Fig. 2. Relation between bearing wedge angle and vertical clearance per flat for various threads per inch and shape of heads

sometimes be made by the man running the engine, but long life of his engines will be more certain if a renewal is ordered from the factory at the same time and installed as soon as possible to replace the emergency job.

Lubrication

Adoption of a few simple safeguards in the plant will postpone almost indefinitely the prospect of shaft or bearing renewal, however, as there are any number of Diesels in service for from 40,000 to more than 100,000 operating hours still running with the original shaft and main bearings. Adequate lubrication is perhaps the most important factor, providing the shaft be kept in perfect alignment. Much wear is sustained at the period of start-up, especially on units which are in stand-by service with down periods long enough for most of the oil to drain out of the bearings and leave almost metal-to-metal contacts for the first revolutions of the engine until the oiling system can get fresh oil to all points.

One power plant, finding this aggravated start-up wear requiring bearing adjustments on the stand-by unit at intervals—measured in operating hours—more than twice as often as on units in 24 hr., 7 da. operation, extended the delivery line from the built-in oil pump through the engine base and mounted a small high-pressure, hand-operated pump there with its suction extended into the engine sump.

Standby Service

When the stand-by was scheduled to replace another of the units it was easy to give this pump a few strokes and fill the lubrication lines with a flow of fresh oil, insuring overflowing sumps at each main bearing and a supply of oil which would quickly be flung from the revolving crankshaft throughout the crankcase to shower all exposed parts of pistons and liners and to coat other rotating parts without the benefit of pressure oiling.

Since this pump drew from the engine sump, and returned its stream within the crankcase, no additional oil supply was required, nor was there any increase in amount of lubricant needed noted after its incorporation in the unit. So effective did the hand pump prove in prolonging periods between bearing attention in the stand-by unit that similar pumps were put on all Diesels within that plant.

An Effective Kink

Where the Diesel is designed with small bore holes or sumps atop the main bearings to catch the oil from the pressure feeds, bearing service can be greatly extended if these holes by loosely filled with a good grade of wool waste. The filler should not be packed in tightly enough to restrict the flow of oil to the shaft, but should be compact enough to trap and retain particles of carbon and metal picked up and carried in the oil stream or deposited atop the bearing in the drip from within the crankcase. Where the engine is on 6 da. service, it will probably be found advisable to pull and replace these improvised filter elements every 2 wk., though in one crude oil main line pumping station the plugs of waste are fitted and renewed only at the time of the monthly shut-down for inspection. This gives an average of over 700 running hours per filter.

An engineer adopting the filter plan will be surprised at the amount of carbon, other foreign matter and heavy sludge trapped by the small ball of waste, a clear gain for the main bearings as otherwise this material would be flowed in against the shaft in a spot where it could not be thrown free by shaft rotation. Escape is possible only by being carried around on the shaft and ground down to where it can flow out within the film of oil between shaft and bearing, inevitably abrasion of the shaft and bearing is the result.

The resultant damage to the engine when a crankshaft breaks often obliterates all identifying characteristics of the fracture, but where the metal at the break has not been hammered or chafed before the engine can be stopped, a study of the grain size at the break will often indicate whether the failure was due to misalignment or some other cause.

If misalignment was present, and the shaft failed through stresses set up by repeated alternated flexure, the grain of the metal farthest from where the hinging effect took place will be relatively large, with the center or node of the bending characterized by extremely small grains. Usually these small grains will be disposed in a line across which the bending occurred, with the metal structure on each side shading gradually up to the largest grains at the outside.

Examine the Break

If a flaw in the metal was responsible for the break, this will show as a discolored spot. The spot may be stained with oil, or may be of mirror-like brightness if at the surface, or due to the composition of the metal at the flaw may grade down as far as a dull black if within the shaft. In either event, the only use such identification of the cause of failure is to the engineer is to guide him in future operation, or to afford him a fulcrum from which to work in prying concessions from the engine builder when obtaining replacement for the damaged unit.

It is much easier for the Diesel engineer to maintain the crankshaft of his engine in proper running alignment and adjustment than it is for him to get it again into proper condition after it has been permitted to operate improperly set or adjusted. A crankcase, once checked and then maintained by careful supervision, should outwear any other of the moving parts of the engine. If it does not, the fault is chargeable to operation in 95 per cent of the cases, and to the maker in the other five per cent.

Table—Vertical clearance given per flat of the adjusting bolt head

Bearing Wedge Angle Deg.	Threads per Inch 4 Bolt Sq.	4 Head Hex	5 Bolt Sq.	5 Head Hex	6 Bolt Sq.	6 Head Hex	8 Bolt Sq.	8 Head Hex
8	8.79	5.86	7.19	4.68	5.65	3.75	4.38	2.92
10	11.01	7.35	8.82	5.87	7.09	4.71	5.50	3.67
12½	13.86	9.24	11.08	7.38	8.91	5.93	6.92	4.61
15	16.74	11.17	13.40	8.92	10.77	7.16	8.36	5.57

Utilizing Diesel Waste Heat

UTILIZATION of waste heat from the exhaust or from the cooling-water system of a Diesel engine does much to increase the overall thermal efficiency of the plant. Such waste heat recovery and utilization is becoming increasingly important and a particularly interesting and very simple installation was recently completed by Sulzer Bros. for a Swiss spinning mill. The installation consists of a 75-hp., 2 cycle Sulzer engine with the cooling water piped so as to supply about 240,000 B.t.u. per hr. to a central heating plant. This heat is sufficient to carry the entire heating load for about 85 per cent of the year and supply about the same percentage of the total yearly requirement.

In this part of Switzerland, heating is required for around 200 days per year as shown by Fig. 1 and waste heat is sufficient to carry the heating load about 170 days. Additional heat during extremely cold weather is supplied by an oil fired boiler hooked-up as shown by Fig. 2. Heat supplied by the oil amounts to about 15 per cent of the total, and, since the Diesel waste heat costs nothing the savings amount to about 13 tons

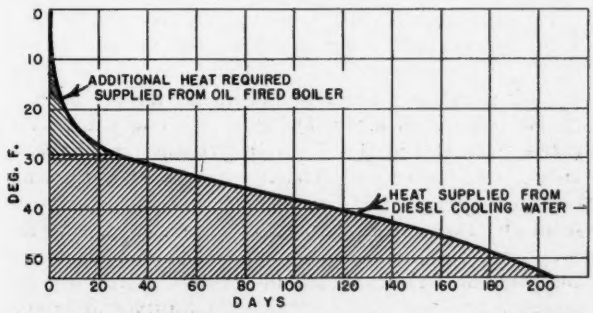


Fig. 1. Curve showing the outside temperature during one heating period and the proportion of the heat supplied from the Diesel engine

(about 3800 gal.) of oil during each heating period. The installation is very simple and generalizing from this limited data, it will be seen that the cost of equipment for heating water can be written off in a year or at most 2 yr. Results obtained have been highly satisfactory even though the engine was occasionally very lightly loaded.

Details of the piping arrangement are shown by Fig. 2. In summer the cooling-water system of the Diesel is disconnected from the heating system by turning the two cocks 1 and 2. When this is done circulating water pump 3 takes its suction from the spray pond and pumps through the engine jacket back to spray nozzle 15.

With the valve turned as shown by Fig. 2 the centrifugal circulating water pump, driven by a belt direct from the Diesel engine, takes its suction from the hot water tank 11, pumps it through the engine jacket to

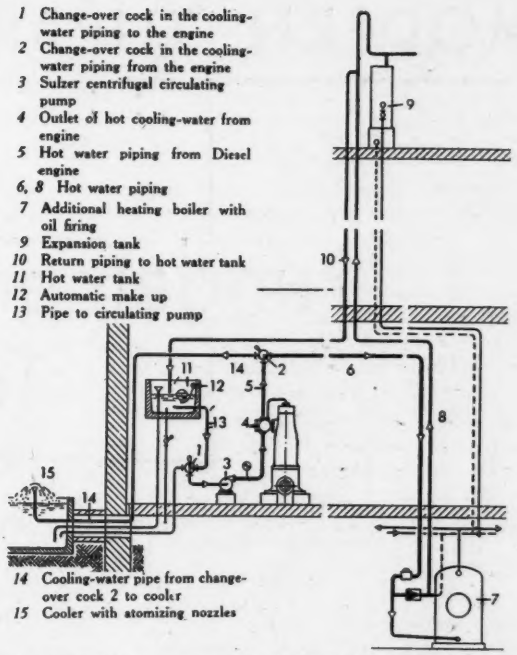

1 Change-over cock in the cooling-water piping to the engine
2 Change-over cock in the cooling-water piping from the engine
3 Sulzer centrifugal circulating pump
4 Outlet of hot cooling-water from engine
5 Hot water piping from Diesel engine
6, 8 Hot water piping
7 Additional heating boiler with oil firing
9 Expansion tank
10 Return piping to hot water tank
11 Hot water tank
12 Automatic make up
13 Pipe to circulating pump
14 Cooling-water pipe from change-over cock 2 to cooler
15 Cooler with atomizing nozzles

Fig. 2. Diagrammatic arrangement of the piping layout for a central heating plant utilizing heat recovered from the Diesel engine cooling water system

the heating system which is adjacent to the oil-fired boiler and at a considerable distance from the engine room. In spite of this arrangement no trouble has been found in transmitting the heat over the intervening distance.

Fuels of Today and Tomorrow

FUELS of Today and Tomorrow was the subject of an address presented at the University of Maryland by Dr. A. C. Fieldner, Chief, Technologic Branch of the Bureau of Mines, Department of the Interior, on March 22.

In this paper it was pointed out that 30 yr. ago, coal supplied 89 per cent of the fuel energy of the United States. Since then, increased efficiency in the use of coal and the displacing effect of petroleum and then of natural gas caused a steady decline in the proportion of energy obtained from coal until today coal supplies only 50 per cent.

The national fuel reserves have been inventories and it is pointed out that the United States produced and consumed 31 to 33 per cent of the world's production of coal, 60 to 70 per cent of the petroleum, and 95 per cent of the natural gas. A little over one-half of the world's reserves of coal and probably 60 per cent of the proved oil reserves are in the United States.

An appraisel of present trends and future probabilities of fuels of tomorrow indicates that coal will continue to be the principal fuel used for the generation of public utility and major industrial power.

Research on the refining of petroleum has been stimulated by the 10 to 12 million dollars spent annually. Even more should be expended on research for the preparation and utilization of coal if it is to regain its former title—King Coal—the undisputed monarch of the fuel world.

MODERN TURBINES

Fundamentals of The Turbine-Generator*

By
J. M. LYONS
Generator Engineering Dept.,
General Electric Co., Lynn, Mass.

A TURBINE-GENERATOR set converts the heat energy of steam into more easily used electrical power. It does this in two steps—first, transforming the energy of the steam into mechanical power in the turbine, and second, converting this mechanical power into electrical power in the generator. Both of these steps are equally important, but they are performed in vastly different types of machines. The turbine is intricate in appearance, extremely flexible in construction to cover a wide range of operating conditions, but the principle of operation is relatively easy to understand. The generator is very simple in appearance, standardized in construction, but the operation is more difficult to explain because it depends on what to many people are mysterious magnetic and electrical principles. A working knowledge of these fundamental principles is essential, however, before a generator can be wisely specified and selected for any given application. It is the purpose of this article to show how these principles determine the type of generator best fitted to any given job.

When you look at the generator directly connected to its turbine, what do you imagine is going on under the cover? Why does the turbine-driven generator have such different proportions from a Diesel-driven or water-wheel generator? How does the mechanical power delivered at the turbine coupling get out onto the line in the form of electrical volts and amperes? Why is the generator all inclosed, and large quantities of air constantly sent through it? Why do two generators of the same capacity have different efficiencies?

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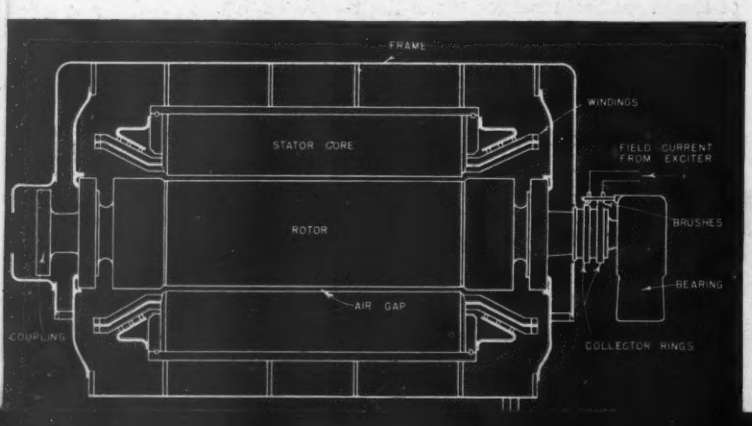


Fig. 1. Construction of a high speed turbine-generator unit showing the relation of the main parts to each other

To answer these questions, and others equally as important, we will first take a short look inside that sleek, streamlined cover in which the turbine driven generator is enclosed. The only sign of activity is a long slender steel body revolving inside a circular bore in the stationary member, and directly coupled to the turbine rotor (Fig. 1). The construction and appearance of this rotor suggests high speed, and it is this feature which most distinguishes the turbine generator from all other types of rotating apparatus. From the very first, the principal effort in design has been to develop generators which could operate at the highest speeds consistent with complete reliability and safety.

Turbine-generators, however, can operate only at certain speeds to give standard frequencies. For the usual frequency of 60 cycles per second these speeds are 3600 r.p.m., 1800 r.p.m., 1200 r.p.m., etc. As turbine designs have been advanced, generator speeds have been stepped up to 3600 r.p.m. for larger and larger ratings, until at present 60,000 kw. units are being built for this speed. The results have been considerable reductions in size and weight together with better over-all efficiencies of turbine-generator sets.

The use of such high speeds must result in relatively small diameters for the rotating element. It should be remembered that at 3600 r.p.m. the centrifugal force exerted by every pound of weight on a rotor at a radius of only 6 in. from the center is more than one ton. Considerations of mechanical strength required to withstand such forces have made small diameters necessary. At the same time considerations of balance and mechanical operation have made it important to keep the length of the rotor as short as possible. The generator

designer has therefore had to make a virture of necessity in solving the many complicated problems involved in the generation of large amounts of power in small, high speed units. In some cases the weight per kw. of a modern generator is only two-thirds of what it was 10 yr. ago.

Now for a second glance inside the generator. The nontechnical observer may be puzzled to find no visible connection between rotor and stator, and will probably wonder why the turbine has to exert so much effort to turn the generator rotor, which apparently runs very freely in its bearings. In fact there is a rather wide air gap of from one-half inch to two or three inches between rotor and stator. He may guess that the power delivered by the turbine shaft must be entirely different in form from that delivered by the generator stator. This is evident because the shaft through which the turbine output is delivered is a strong alloy steel forging with a cross-section of, say, one hundred square inches and a tensile strength of 100,000 lb. per sq. in., while the conductors through which the generated power is delivered are relatively weak copper bars with a total cross-section of, say, three square inches (for a 13,800-v. generator), and a tensile strength of 35,000 lb. per sq. in. Fig. 2 shows these relative cross-sections side by side for comparison. The generator power is proportional to the product of volts and amperes, while the turbine power is proportional to the product of speed and torque. Letting speed correspond to voltage and torque to current, it would be necessary to increase the speed of a 3600 r.p.m. turbine to about 700,000 r.p.m. in order to deliver its rated power through a *steel* shaft of the same section as the *copper* leads for the 13,800-v. generator it drives! While this illustration is of course fanciful, it does indicate that an important transformation in kind of power is made somehow in the generator, and it is necessary to describe how the change is made.

The magnetic field is the agency by which power is converted from mechanical to electrical form, and which determines most of the operating characteristics of the generator. It is to the generator what steam is to the turbine—the controlling factor in its operation. How is a magnetic field produced? It can be produced in two ways—by permanent magnets like the familiar horseshoe type, or by coils of wire carrying electric current. In a turbine-generator the field is produced by coils of wire embedded in the rotor, and arranged to produce alternate north and south poles around the rotor periphery, (Fig. 3). There is always an even number of such poles and the generator is classified by their number, i.e., 2-pole, 4-pole, etc. The rotor can be thought of as a large and powerful magnet whirling around at high speed inside the generator and producing a strong magnetic field of the same nature as that produced by the familiar bar or horseshoe magnet.

The current required to produce the field is always direct current, and is led into the rotor winding through brushes bearing on collector rings on the end of the rotor as shown in Fig. 1. The magnetic field crosses the air gap and passes through the stationary core before returning to the rotor again to complete the circuit. In passing through the stator core it crosses coils of wire embedded in slots around the inner edge of that core. Electrical voltage is thus induced in these coils, and when they are properly connected to the external electrical system, currents are made to flow through the coils and out to the connected load. The magnetic field is thus the link between the rotor and the stator—an invisible link, but certainly not a "missing" one!

Although the magnetic field is invisible and has no apparent effect on bodies through which it passes, yet it can exert strong mechanical forces on iron or steel objects in its path. This can readily be seen when it is remembered how the steel keeper of a horseshoe magnet is strongly attracted to the poles when it is brought near to them. Like water, and electrical current, a magnetic field always tries to find the path of least resistance. If it is forced out of that path it will exert actual mechanical force to get back in it again. Hence it pulls the keeper toward the poles to bridge the air gap and make a better path. In a turbine-generator

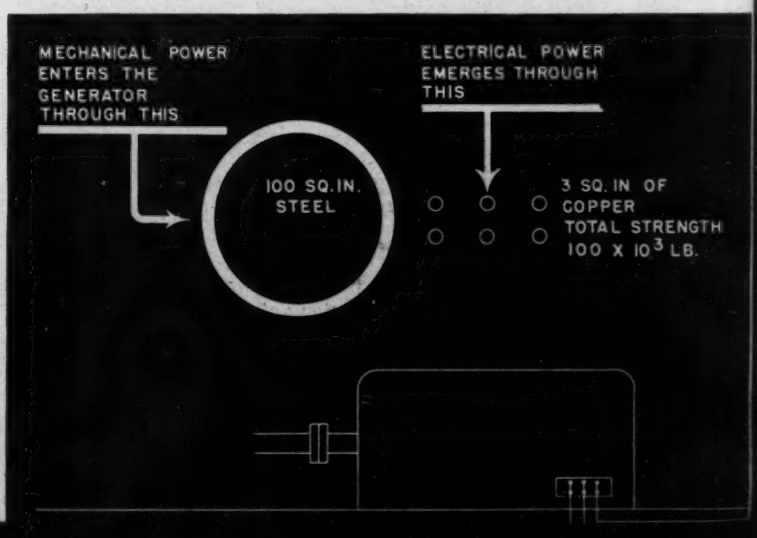

MECHANICAL POWER ENTERS THE GENERATOR THROUGH THIS
ELECTRICAL POWER EMERGES THROUGH THIS
100 SQ.IN. STEEL
3 SQ. IN OF COPPER
TOTAL STRENGTH
100 X 10³ LB.

Fig. 2. Relative cross-sections of steel shaft and copper conductors for transmitting equal amounts of power into and out of the turbine-generator

ATTENTION! A GUEST AUTHOR

THIS MONTH we tear a sheet right out of radio—and present a guest artist, or more correctly, a guest author on Mr. Newman's regular Turbine program. He is none other than General Electric's inimitable J. M. Lyons, who knows a thing or two about generators and also knows how to tell them so you can understand them.

Mr. Newman knows how to play tunes, do hand springs and slight-of-hand tricks with turbines. He also modestly admits that he knows some other things too, but boasts that he is a Missourian and feels that if this series is to be held at the standard he set for it, a specialist should cover those parts of the turbine-generator that form a component part of the unit, yet are distinct from the turbine itself.

So, this month, he steps aside to let Mr. Lyons explain the mysteries—and believe us they are mysteries—of the generator, that smooth, sleek looking gadget at the end of the turbine shaft. Mr. Lyons is the first of several specialists who will appear on Mr. Newman's program in this manner.

In this first of several articles on the generator he outlines the fundamental facts which an operator should be familiar with. Other principles and facts which enter into the proper choice and successful application of a turbine generator will be covered in subsequent articles.

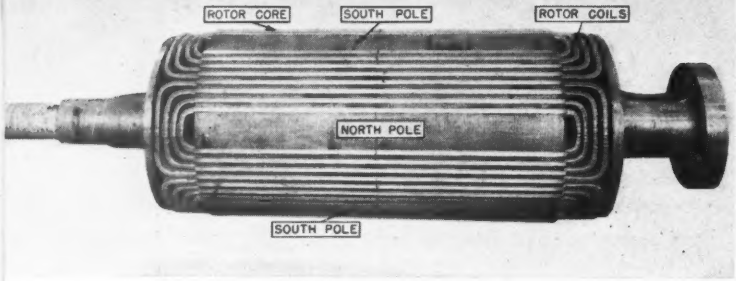


Fig. 3. Arrangement of rotor coils to form alternate north and south poles around the rotor core

under load the armature[1] currents produce a reaction on the magnetic field which forces it out of its easiest path through the rotor poles. True to its nature the field then exerts a force on the rotor itself trying to pull it back so that the field *can* go through the center of the poles again. *The mechanical force produced by the turbine is used to keep the rotor from slipping back to accommodate the magnetic field.*

At such times the magnetic field acts like an elastic spring and the force it exerts increases with the amount of shift just as the restoring force of the spring increases with the amount it is stretched. This simple analogy is shown schematically in Fig. 4. In the generator the restoring action is called "synchronizing power" and the shift of the field from its no-load path, corresponding to the stretch of the spring, is measured by an angle known as the "load angle." It is important to get this physical picture of power transfer in a generator firmly fixed in mind because it will then be easier to understand later discussions of generator "stability" and other related items.

The direct current required to excite the rotor coils so they will set up the magnetic field is called "field current." This current is furnished by a direct current generator either driven directly from the generator shaft, or else forming part of a separate motor or turbine driven set. *The field current can easily be adjusted in amount independent of load, voltage, or speed on the main generator.* The adjustments so made are extremely important in the proper operation of the generator, and it is therefore necessary to know just what may be expected to happen when the field current is changed.

Before getting into this subject, however, it is necessary to say something about "power factor." Most turbine generators are of the A-C type which deliver alternating current and voltage, and the alternations in current may be shifted out of phase with the corresponding alternations in voltage, depending on the nature of the load circuit. In such cases the current and voltage do not act exactly together in producing electric power, and it is reasonable to suppose that the power produced is less than if they were exactly in phase. The reduction is measured by a ratio called "power factor," which is the ratio of power in watts or kilowatts to the product of volts and amperes in "volt-amperes" or "kilo-volt amperes" (written Kv-a.). This ratio can vary from 0 to 100 per cent. Induction motors, transformers, and electric furnaces[2] cause the current to lag behind the voltage, giving rise to "lagging" power factor. Incandescent lamps, or any pure resistance, cause no phase shift and their power factor is "unity." Capacitors and synchronous condensers cause the current to lead the voltage, and cause "leading power factor." *The power factor of the load attached to a generator determines how much field current must be carried on the generator to deliver the required kilowatt load at the required voltage and frequency.*

A study of the problem shows that when the generator is operating in parallel with other generators the laws governing the variation in field current with changes in various armature conditions at constant speed can be summed up as follows:

1—At constant generator current and voltage an increase in field current is req ired to lower the power factor in the lagging direction from unity to zero.
2—At constant generator current and voltage a reduction in field current is required to lower the power factor in the leading direction from unity to zero.
3—At constant generator voltage and power factor an increase in field current is required to increase the armature current, and vice versa.[3]
4—At constant armature current and power factor an increase in field current is required to increase the voltage, and vice versa.

The above rules cover independent variations in each of the three operating conditions—armature voltage, armature current, and power factor. It is sometimes supposed that if the Kv-a. output of a generator (voltage times current) is kept constant, the field current can also be kept constant. This is not always true, as the following two rules will show:

1—At constant kv-a. and constant voltage the field current must be increased in order to carry a more lagging power factor, and vice versa.
2—At constant kv-a. and constant power factor the field current must be increased to increase the voltage, even though a proportionate decrease in armature current is made at the same time to maintain the kv-a. constant.

A brief physical explanation of these factors will help to fix them firmly in mind.

At constant speed the voltage induced in the armature winding is proportional to the magnetic field producing it. The field current producing this field, however, is not always proportional to the strength of the field, and the familiar "saturation curve" of a generator shows how much field current is needed to produce any required armature voltage when no armature current flows (Fig. 5). This curve shows that the field current increases faster than the voltage increases in the normal operating region, and, conversely, decreases faster than the voltage decreases in the same region. It should be understood

[3]Except at low power factor leading.

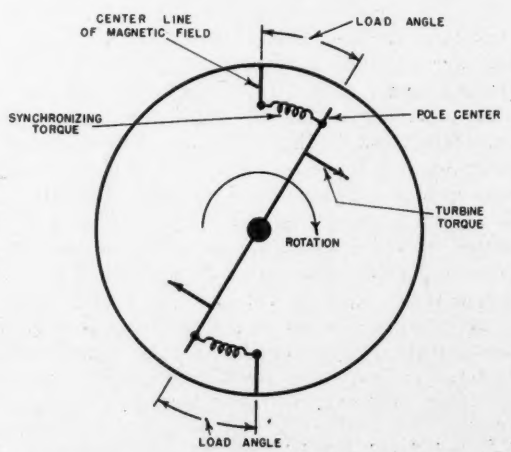


Fig. 4. Analogy between synchronizing torque and action of elastic spring

[1]The term armature in the case of a turbine-generator refers to the stationary member or stator. (Ed.)
[2]The electric furnaces referred to here are arc type furnaces not resistance type furnaces which have unity power factor. (Ed.)

that in the unsaturated region at the lower end of the curve the field current increases or decreases at the same rate as the voltage.

When armature current flows, it produces a reaction on the magnetic field, so that in order to maintain a given voltage it is necessary to change the field current from the value required at no load for the same voltage. This reaction is proportional to the armature current which produces it.

The field current can therefore be conveniently considered as made up of two parts—one required to produce the necessary magnetic field, and the other required to balance out the effect of the armature current. An increase in armature current requires more field current to balance out the increased reaction.[4]

The effect which armature reaction has on the field current depends on the power factor as well as on the amount of reaction. The following general rules hold true for the effect of power factor:

Power Factor	Armature Reaction
Zero—lagging	Directly opposes field.
Lagging—0 to 100%	Opposes field with decreasing effect.
Unity	Distorts field and opposes it less than at lagging power factor.
Leading—100% to 0	Aids field with increasing effect.
Zero—leading	Directly aids field.

These facts help to explain some of the rules given above.

It is interesting at this stage to note the relative values of variations in field current to make some typical variations in armature conditions. A normal 80 per cent lagging power factor two-pole generator will be selected. Table I gives a tabulation of the relations which might hold for such a generator:

TABLE I—VARIATIONS IN FIELD CURRENT CORRESPONDING TO SOME TYPICAL LOAD VARIATIONS

Voltage	Current	KW Output	Power Factor	Field Current
Constant (Normal)	Increased from 0 to full load	Increased from 0 to full load	Constant (80% lagging)	Increased 100%
Increased 5%	Decreased 5%	Constant (Normal)	Constant (80% lagging)	Increased 4%
(Constant kv-a.)				
Constant (Normal)	Constant (Normal)	Decreased to 87.5% normal	Decreased to 70% lagging	Increased 5%
(Constant kv-a.)				
Constant (Normal)	Constant (Normal)	Increased to 125% normal	Increased to Unity	Decreased 25%
(Constant kv-a.)				
Constant (Normal)	Decreased to 80% Normal	Decreased to 0	Decreased to 0 lagging	Constant (Normal)

The variations shown in this Table are only a few of many which can be made. They illustrate one or two important points, however. The second line shows the effect of even a small increase in voltage at constant load and power factor, and it must be remembered that the 4 per cent increase in field *current* means nearly 8 per cent increase in field *heating*.[5] The third line shows that to carry a power factor only 10 per cent below normal requires 5 per cent more than rated field current and results in nearly 10 per cent more than normal field heating. This happens even though the kilowatt load is reduced by 12½ per cent of its rated value to maintain normal armature current at the normal voltage. If an attempt is made to run full kilowatt load at 70 per cent power factor (and normal voltage), the field current must be increased 15 per cent above normal and the field heating will be nearly 30 per cent greater than the generator is designed for. Hence, if low power factor conditions develop it is desirable to remedy the situation immediately by installing capacitors or synchronous condensers to improve the power factor.

From the above it can be seen how important in the electrical operation of the generator is the proper adjustment and control of field current. One thing, however, which cannot be done by changing field current is to change the load carried by the generator. *No amount of juggling with field rheostats will affect the kilowatt output of a turbine-generator operating in parallel with other generators.* This can only be changed by varying the weight flow of steam through the turbine. In other words, *weight of steam flow with constant steam conditions determines power output; at a given load field current determines voltage, current, and power factor.*

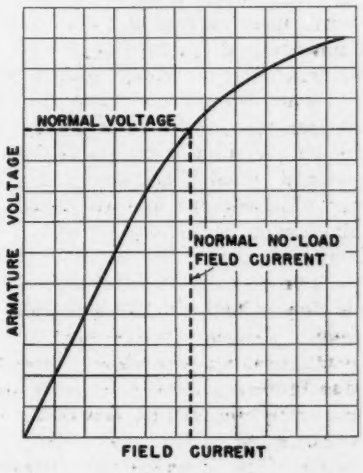


Fig. 5. No load saturation curve typical turbine generator

Earlier in this article attention was directed to the compact construction of the turbine-generator and its total inclosure. How and why is this done? The compactness is the result of high speed, small diameters, and the careful design required to make the length as short as possible. This feature of turbine-generators, however, makes it more of a problem to cool the windings. Even though such generators are very efficient, they do have some losses, and it is necessary to force relatively large quantities of a cooling medium through them to carry off the heat occasioned by the losses, hence the inclosed construction. Furthermore, in order to prevent clogging of the relatively narrow ventilating passages in the machine by dust and oil from outside, it is now general practice to recirculate the air in a totally inclosed system and to cool this air with air coolers inserted in the system at suitable locations (Fig. 6). This freedom from dirt and oil lengthens the life of the insulation and, by allowing the full design quantity of air to flow all the time, makes for a cooler generator.

The losses in a turbine generator can be briefly described as follows. The principal loss in high speed generators is the air friction loss on the rotor surface called "rotation loss." It varies nearly as the cube of the speed and as the fourth power of the diameter, and in large machines becomes one of the limiting features of the design. Another loss due to the air flow is the

[4] At lagging power factor.

[5] The loss in the field winding is proportional to the square of the current, and the heating is nearly proportional to this loss. ($1.04^2 = 1.08$ approx.).

power required to drive the fans which are mounted on the rotor to force air through the generator. The combination of rotation loss and fan input in air cooled machines is the largest single item of loss, amounting to about one to two per cent of the kilowatt rating, and is independent of load or voltage.

Another important loss is the "core loss" in the stator core. This is due to the continual reversals of magnetic field in the steel core and to the fact that power is required to make such reversals. Building up of the core with very thin laminations and the use of high grade silicon steel serve to keep this loss down to a reasonable value, usually from one to two per cent of the kilowatt rating. This loss is independent of load, but varies about as the square of voltage and the first power of frequency for any given voltage.

The ohmic resistance losses in the armature and rotor windings due to the flow of current through the winding resistances make up another, though smaller, item. These losses increase with load, since they depend on armature current and field current. They comprise about one-half per cent to two per cent of the kw. rating depending on the size of generator.

Finally there are a group of parasitic losses in various iron and steel members adjacent to the windings, and on the rotor surface. These are lumped into one quantity called "load loss." It varies in an obscure way with current and frequency, and is difficult to calculate or measure.

Fig. 7 shows the relative sizes of these various losses graphically at different loads, both for a 500 kw. and for a 5000 kw., 2-pole, 3600 r.p.m. generator of modern design. Notice how the "constant" losses (friction, windage, and core loss) become increasingly important at partial loads, showing that good partial-load efficiencies can be obtained only by reducing these losses.

All of these losses are dissipated as heat in the generator. By careful design and the use of better materials, the amount of cooling air required to carry off the heat caused by the losses has been constantly decreased until now it is possible to properly ventilate with about 70 to 100 c.f.m. of air per kw. loss. Even

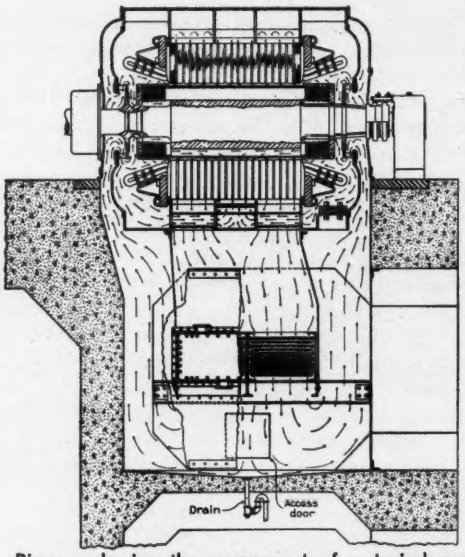


Fig. 6. Diagram showing the arrangement of a typical generator cooling system

so, the amount of air required in even a 97 or 98 per cent efficient generator is startling. The average present day generator circulates a weight of air equal to its own weight every 45 min., while the air required at full load by the largest generator yet built is about 1,000,000 lb. per hr.

The losses described above occur both in the stator and the rotor, but those occurring in the rotor are much more difficult to remove. The rotor is a long slender body in which all of the winding losses must be brought to the surface and dissipated to the cooling medium. The heat flow paths are necessarily restricted and the temperature difference between copper and outside air is allowed to go as high as 85 deg. C. (185 deg. F.). The heating of the rotor winding is generally the limiting feature in generator design.

The use of hydrogen as the cooling medium reduces the rotation loss to about 1/10 of normal, thus reducing the temperature rise of the cooling medium inside the machine, while at the same time it removes heat from the rotor surface about twice as well as air with the same velocity and pressure. The development of the largest 3600 r.p.m. generators has been made possible largely by the application of hydrogen as the cooling medium. However, hydrogen cooling requires more expensive hydrogen-tight construction and various hydrogen auxiliaries, and the use of hydrogen cooling is usually not economical in ratings below 25,000 kw.

The solution of these ticklish problems in heating and ventilation is typical of the many specialized developments which make the present day turbine-generator possible.

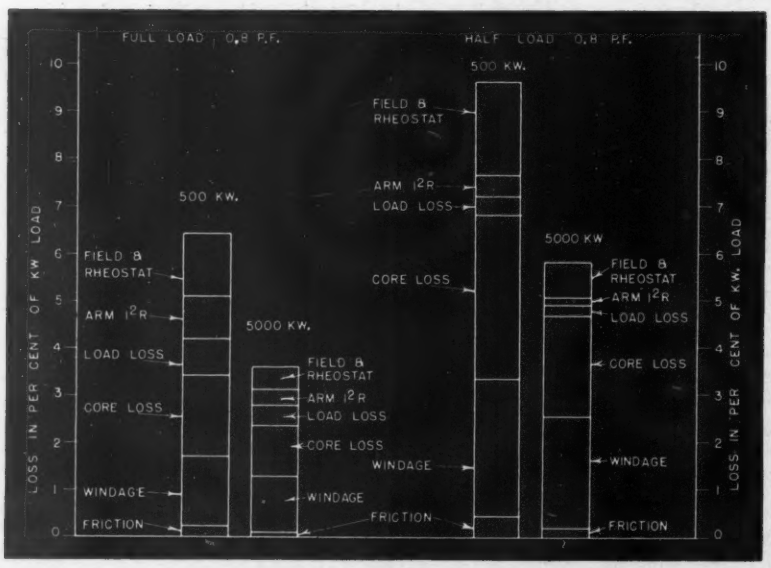


Fig. 7. Relative percentage of various losses in two typical 3600 r.p.m. turbine-generators at full load and half load

Improvements in power plant servicing processes used in the evaporation of milk and the making of beer.

Plant Study Yields Worthwhile Earnings

BY RALPH A. SPENGLER

Industrial Engineer, Cleveland, O.

TO DETERMINE the advisability of carrying out a modernization program a comprehensive study was made of the power plant used jointly by the Defiance Milk Products Co., which evaporates whole milk to one-half of its volume before it is canned, and the Crist Diehl Brewing Co., which produces beer. This study, covering the boiler plant, engine room, and purchased power, showed that a new boiler would earn its investment cost in 5 yr. and—of utmost importance—make certain continuity of service. This installation was made last year. This year, the refrigeration operations were revamped.

In order better to understand what changes were made to effect savings, it will be well to know how the process was carried on before any changes were made:

In the milk plant, milk is received in 10-gal. cans from the farmers. It is weighed in and a sample is taken of each farmer's milk.

The evaporator pans are two in number, 7 ft. diameter. They are each equipped with the conventional horizontal baffled condenser and a wet vacuum pump. The copper heating coils are each valve controlled.

The milk leaves the pan continuously and raw milk is added. The milk drawn off has the desired amount of moisture removed. It passes next to the homogenizers, on its way to the Bandelot coolers. From the coolers, it is stored ready for canning. From the canning machines the milk is sterilized, labeled, boxed and stored or shipped, as the case may be.

The equipment for cooling the milk consisted of a 40-ton Linde-Wolf compressor, driven by a Corliss engine and a 9 by 9 motor driven York compressor. The condensers were the vertical type, with water from the river flowing down inside of the tubes.

In the summer, when the load is greatest, it was necessary to operate both machines. The head pressures were often as high as 215 lb. average. The ammonia is used to cool the brine which is circulated through the Bandelot cooler in the pan room, the beer cooler in brewery, and the beer storage cellars. The exhaust steam from the engine was used to evaporate the milk in the pans, heat water for brewing, feedwater for boiler, etc. At the time when the pan was not in operation, the steam was exhausted to the air. With brine system, the suction pressures on the compressor varied from 5 to 15 lb.

The water used on the ammonia condensers went directly to the sewer, as did also the water used by the condenser on the pans. In warm weather it required 1500 g.p.m. to supply these two pieces of equipment. The water is pumpd from the river with steam driven pumps.

The steam required by the plant last year many times exceeded 33,000 lb. per hr. This steam requirement is reached only when two pans are in operation.

The changes, after a comprehensive study had been made, consisted briefly of the following:

1. The revamping of one pan.
2. Installation of horizontal condensers.
3. New milk coolers equipped to operate with sweet water as a cooling medium.
4. A new engine driven compressor.

Revamping of the Pan

At this time only one pan was modified. The second pan will be changed later, should the plant require more capacity. The dome of No. 1 pan was raised 3 ft. and an additional copper coil was installed. The horizontal baffled condenser was moved to the floor above and used as a separator. This was connected to a new barometric condenser. The old vacuum pump was connected to the top of the barometric condenser to serve as a dry vacuum pump for removing the air. The condenser tail pipe was terminated in a sump, which was connected to the sewer.

The condenser requires approximately 850 g.p.m. of cooling water when the pan is in full operation (cooling water at a relatively high temperature, 90 deg. F.).

New Condensers

The vertical shell condensers were kept in operation until the new closed type of condensers were installed. These units were placed in a spare room, adjacent to the pan room. The new condensers were built by the Henry Vogt Co. and consisted of 4 shells, 18 in. diam.,

18 ft. long, placed in groups of two. Space was provided for additional condensers as the plant capacity increased. Each shell was individually controlled in all respects. This made it possible to take one shell out of service for cleaning without interrupting the plant's operation. With three shells in service, there is ample capacity to maintain good head pressures when the plant is fully loaded.

The river water is pumped directly to the condensers. From the condensers the water is conducted to the barometric condenser in the pan. The amount of water required by the ammonia condensers is slightly less than that required by the barometric condenser. By making this connection, the cooling water serves two purposes: That of cooling the ammonia and condensing the vapors from the pan.

The two large storage tanks located under the roof of the building float on the line. If more water is pumped than is required by the condensers, it is stored in these tanks. When there is a sudden demand for water elsewhere in the plant, these tanks make up the deficiency. Inspection of the line diagram makes this clear.

The ammonia receiver was located in the engine room so that the operator could observe the ammonia level readily. Equalizer lines were run back to the condensers. These lines can be used for pumping out the condenser, receiver, etc.

Milk Coolers

The old Bandelot coolers were replaced with two Cherry Burrell cabinet type coolers. Each cooler consisted of four sections high and nine plates deep. The cabinet has capacity for two additional plates, should they be required. The cabinets are so piped up that river water can be used on all of the sections, or sweet water can be used on the fourth and third sections and river water on the other two sections. In winter and spring, when the river water is cold, no sweet water is used, but as the temperature of the river water rises, one or more sections of sweet water are used.

The sweet water is cooled in a Henry Vogt vertical shell cooler; a pump draws the water from the storage tanks, delivering it to the milk cooler, thence over to the vertical cooler tubes. The use of 32 deg. sweet water rather than brine allows the vertical cooler to operate on 45 lb. suction pressure. This is an advantage, as will be pointed out later.

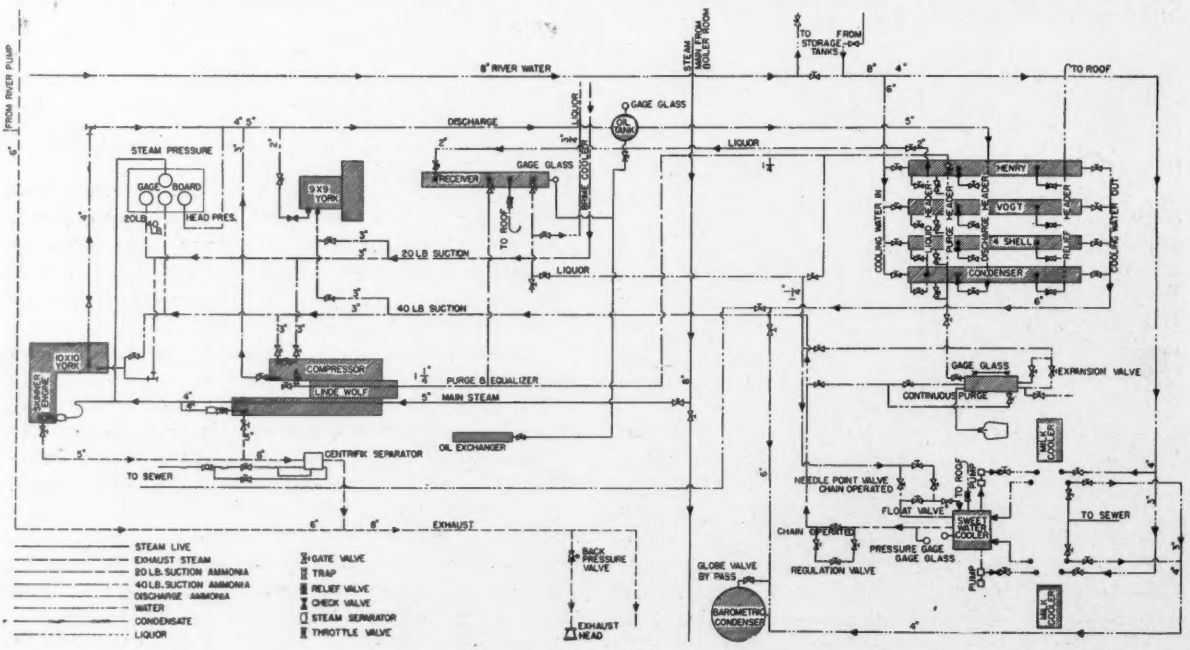
The river water, after passing through the Cherry Burrell cabinet cooler, is delivered to the barometric condenser. The water from the ammonia condenser and the milk coolers gives sufficient water for good operation of the barometric condensers. The amount of water pumped from the river is practically 50 per cent less than previously used. This operation has reduced the steam requirement materially, which, of course, is reflected in the amount of coal purchased.

New Compressor

In the engine room the Linde-Wolf compressor was completely overhauled. The main journal boxes were rebabbitted, the shaft was turned, the valve link motion was bushed, and new plate valves were installed in the ammonia compressor. This work made this unit as good as new.

A new 10 by 10 York compressor, driven by a Skinner engine, was installed. This installation made it possible to eliminate purchased power used by the 9 by 9 York compressor.

It is necessary still to use the brine cooler for the making of beer, so the plant has two suction pressures: 5 to 15 lb. for the brine cooler and 45 lb. for the sweet water cooler. The piping has been so arranged that these two suction pressures may be used on any of the compressors. In the case of the Linde-Wolf machine, one end of this unit can be receiving ammonia gas at 5 to 15 lb. and the other end 45 lb. gas. With this



Diagrammatic Piping Layout of Defiance Milk Products Co. plant

arrangement for practically three-quarters of the year, the Linde-Wolf machine can cool the milk and beer. The higher suction pressure made possible by the sweet water cooler increases the capacity of this machine nearly 100 per cent.

As the refrigeration load increases in the summer, it is necessary to crack the by-pass valve between the two ends of this compressor, so that the unit may carry the milk-cooling load and approximately one-quarter of the beer-cooling load. At this season, the 10 by 10 York machine is used to carry the remainder of the beer-cooling load.

All the exhaust steam from two units is used to evaporate milk. Heretofore, it was necessary to operate the Linde-Wolf machine nearly all night. The exhaust from the engine went to the atmosphere when the pan was not in operation. For practically 14 hr. out of the day, steam was being thrown away. Now it is different. When the milk plant is through with its day's run the engines are shut down. This saves steam and all condensate is returned to the feedwater heater. The amount of treated make-up water is materially reduced. When the exhaust steam pipes were rearranged, a Centrifix separator was installed to eliminate the oil and moisture from the engine exhaust. The unit reduces the load on the feedwater filters and delivers dry steam to the pans.

SUMMARY

1. It has been found that the one pan has ample capacity to process all the milk they receive. The second pan has not been needed.

2. The maximum steam requirement has not exceeded 25,000 lb. per hr.

3. More milk has been processed this year than last year and the operating cost for coal and power has been reduced to such an extent that the return on this investment has shown worthwhile earnings.

Shasta Dam, Second Largest in World

REVISED PLANS for Shasta Dam, key unit of the vast Central Valley project in California, will make it the second largest concrete dam in the world, according to a report by John C. Page, Commissioner of Reclamation, Department of the Interior.

The design approved by Bureau of Reclamation engineers calls for a straight-gravity concrete dam approximately 560 ft. high and 3,100 ft. long, to be erected across the canyon of the upper Sacramento River 13 miles north of Redding, California. Shasta Dam will back up the waters of three rivers—the Sacramento, Pit and McCloud—a distance of 35 miles to create a conservation reservoir with a storage capacity of 4,500,000 acre-feet.

Construction of the dam, designed to bring multiple benefits of improved irrigation, flood control, navigation, salinity repulsion and power generation to California's semi-arid Central Valley, must await prior reconstruction of 37 miles of the Southern Pacific Railroad now located within the proposed reservoir site. Mr. Page said negotiations now under way between the Government and the Southern Pacific probably would reach a satisfactory conclusion in time to start the railroad work soon after the first of the year.

As originally planned by State engineers, Shasta Dam was to be about 500 ft. high, creating a reservoir of approximately 3,000,000 acre-feet. On the basis of recent comprehensive studies of the economic height, considering the water resources and the manifold requirements, Chief Engineer R. F. Walter of the Bureau of Reclamation approved a recommendation for a reservoir of 4,500,000 acre-ft.

This storage capacity at the selected site requires a dam with a crest elevation 543 ft. above the present lowest bedrock determined by foundation exploration. After excavation for the necessary cut-off wall below bedrock, the dam will rise probably about 560 ft. above the lowest foundation.

Shasta Dam's only rivals in size will be mighty Boulder Dam on the Colorado River and Grand Coulee Dam under construction on the Columbia River, both under the jurisdiction of the Bureau of Reclamation.

In height, Shasta will be second to Boulder, which is 726.4 ft. high. Grand Coulee will be 553 ft. high. On the crest, Shasta will be more than twice as long as Boulder—3,100 ft. compared to 1,282 ft.—but not so long as Grand Coulee's 4,200 ft. In mass, Shasta will require approximately 5,700,000 cu. yd. of concrete, which is considerably more than the 4,360,000 cu. yd. in Boulder Dam and power house, but not comparable to the 11,250,000 cu. yd. now being placed in Grand Coulee Dam and power houses.

Next to these three giants is the Chambon Dam in France, 450 ft. high, followed by Hetch Hetchy Dam, a part of San Francisco's water supply system in the Sierra Nevadas, which recently was heightened to 427 ft., and Owyhee Dam in eastern Oregon, another Bureau of Reclamation structure, 417 ft. high.

Walker R. Young of Sacramento, the Bureau's construction engineer for the Central Valley project, who also was the construction engineer on Boulder Dam, said Shasta Dam will require concrete enough to build a solid monument a city block square and slightly higher than New York's Empire State Building. He said it would take a freight train more than 200 miles long to haul the cement to be used in mixing this concrete; and that Shasta Reservoir, when full, will hold water enough to cover the entire City of Chicago to a depth of 35 feet.

Incidental to the primary functions of Shasta Dam will be the generation of about a billion and a half kilowatt-hours of electricity annually. The initial hydroelectric installation will be for 280,000 kw. (375,000 hp.) capacity, with provision for future enlargement to 350,000 kw. (470,000 hp.).

Shasta Dam will be one of two large concrete dams on the Central Valley project. The other, Friant Dam on the upper San Joaquin River east of Fresno, California, will be 260 ft. high and 3,330 ft. long, creating a reservoir of 450,000 acre-feet. Shasta and Friant Reservoirs will be operated to conserve and regulate the principal water resources of the combined Sacramento and San Joaquin river valleys to serve a rich agricultural empire partially threatened with reversion to desert by drought and salinity. More than a million acres in the Sacramento and San Joaquin basins face an acute water shortage which is expected to be relieved by the Central Valley project.

PART XXIV

More facts about amplifiers. How to use them for various purposes. Methods of classification and types of circuits used.

ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

THE FIRST important application of the electron tube and still perhaps its most universal application was that as an amplifier—an amplifier of the extremely weak but complex electric currents used in the transmission of speech over telephone systems. This was its first major general application and as described in an earlier chapter[1] it resulted in benefits to mankind which can scarcely be measured in terms which we usually associate with value. Overnight, almost, it revolutionized the art of telephony, extending the limits of voice transmission to the farthest reaches of the earth; it made round-the-world telephony an actuality. Since that time when it was first impressed in service as a "repeater" by the telephone engineers, electron tubes have been applied as amplifiers of electric currents and impulses in countless other services and though the requirements in these services vary widely, still the principles involved in all these applications are essentially the same. There are differences, however, and these should be understood.

Several amplifier applications and the principles involved have already been described, but the correct

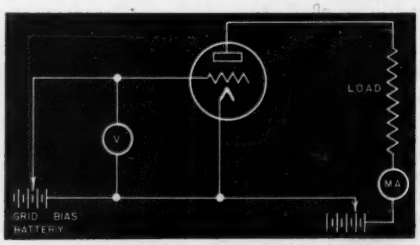


Fig. 2. The elements of an amplifier circuit showing the use of a grid bias battery for adjusting the negative potential of the grid.

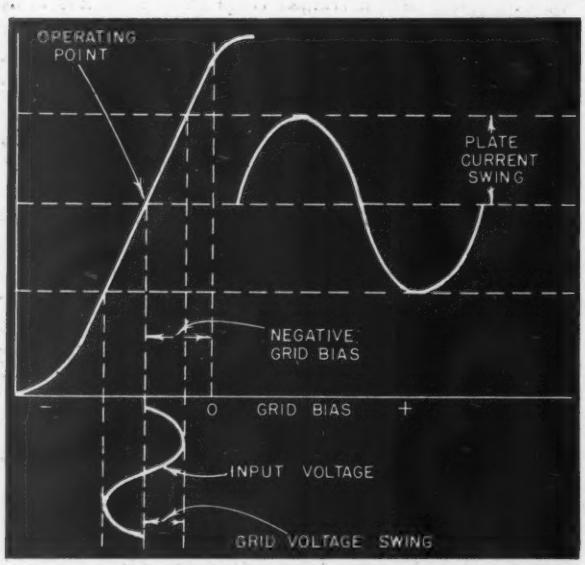


Fig. 1. The operating characteristics of an electron tube amplifier. This diagram represents the action of a Class A amplifier. Plate current flows all the time, whether the grid is excited or not

use of amplifiers requires a more detailed knowledge of the way in which tubes can be used to fulfill certain requirements. Amplifier requirements vary widely. Sometimes, as in "counting" operations, all that is required is the amplification of single or multiple impulses, in which case the tube functions primarily as a relay. At other times the output of the amplifier must reproduce faithfully, without distortion, the shape of an alternating current wave applied to the input. Sometimes, mere amplification of potential is desired, at other times actual amplification of power is necessary.

For most industrial applications where the electron tube is used primarily as a relay, only the simplest principles apply, but in other applications, where the amplified current must be an accurate, amplified reproduction of the input current, a more intimate knowledge of tube characteristics is desirable or necessary.

Now, this need not scare you. It does not imply that the discussion which follows is essentially more

[1]Part V. June, 1936.

difficult of understanding than that which has gone before. It means only that we are going to build on the knowledge we have already gained.

As pointed out in preceding chapters of this discussion, the manner in which an amplifier tube is operated to fulfill certain conditions depends largely upon the way the grid is biased, that is, upon the value of the negative potential applied to the grid. This principle of changing a triode's operating conditions by

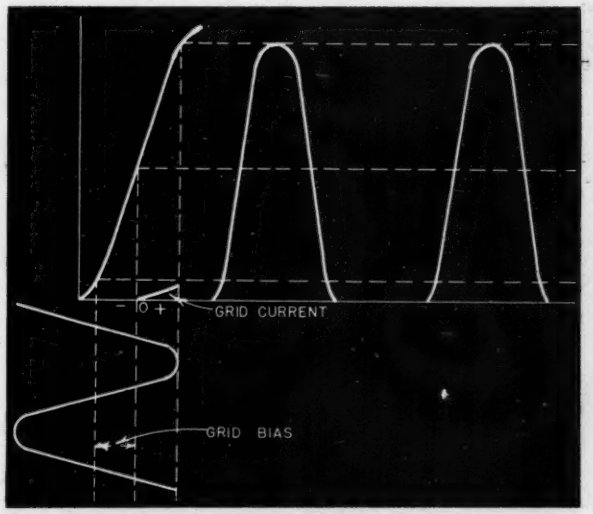


Fig. 3. Class B Amplifier Operation. This shows Class B action. The grid bias is adjusted so that when no exciting potential is applied the plate current is zero or very nearly zero

varying the negative potential of the grid was discussed in some detail in Chapter IV.[2] It may be recalled that the operation of an electron tube as an amplifier can be represented, graphically, by plotting the plate current at right angles to the grid potential in the manner shown in Fig. 1. This diagram makes use of the plate current-grid voltage characteristic. With any given value or type of input voltage such a curve will show the character of the current which will flow in the plate circuit under certain conditions of plate voltage.

If the grid of an amplifier tube is biased properly negative so that the peak input voltage as shown by Fig. 1 will not cause the grid potential to become positive at any point in the cycle or cause the plate current to traverse the lower curved part of the characteristic on the negative half cycle, the output wave will be an exact but amplified reproduction of the input wave. In other words, under these conditions the amplification will be distortionless.

Now it will be noted that the input voltage oscillates about an axis which is displaced negatively from the zero bias point. This displacement represents the grid bias, that is the fixed negative potential of the grid with respect to the cathode. Assuming that an alternating potential is to be amplified, the relative values of the alternating potential with respect to the cathode can be varied from zero by means of a grid bias potential obtained from a battery or other source, as shown in Fig. 2. By increasing the negative potential of the

[2]May, 1936.

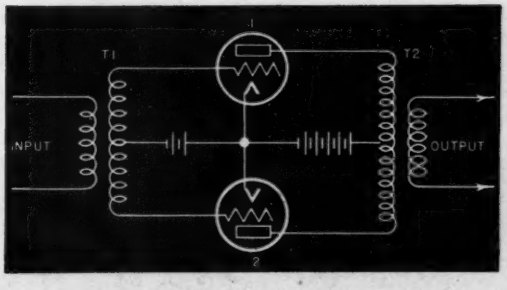


Fig. 4. Circuit using two tubes in "push pull" to provide distortionless amplification with tubes used as Class B amplifiers

grid, the axis of the grid input voltage wave in Fig. 1 is shifted to the left; by decreasing it or by making it positive with respect to the cathode, the axis is shifted towards the right. The cathode, it must be remembered, is always considered the zero potential reference point. In either case, when the amount of the shift is such that critical values are reached (where the projection of the grid voltage values intercept the lower or upper curved portions of the characteristic) the shape and character of the plate current curve is altered, i. e., it becomes distorted and is no longer an accurate amplified reproduction of the grid voltage curve.

An amplifier operated in the manner shown in Fig. 1, in which the output wave shape is a faithful reproduction of the input wave shape, is known as a *Class A* amplifier. It is one of the three fundamental types of amplifiers, the other two being designated as *Class B* and *Class C*.

This classification of amplifiers depends primarily on the fraction of the input cycle during which plate current is expected to flow under rated full load conditions. A Class A amplifier is an amplifier in which the grid bias and the exciting grid voltage are such that plate current flows through the tube all the time. Even with no input there is a steady normal plate current, the value depending upon the grid bias. Because of this, the fact that plate current flows in the absence of an exciting voltage, the plate efficiency[3] is relatively low, being in the neighborhood of 20 to 35 per cent at full output. The plate efficiency cannot be greater than 50 per cent, since the normal plate current must be such as to permit the full amplitude of the negative half of the cycle without at any time reaching zero. The chief characteristics of the Class A amplifier are low distortion, low power output for a given size tube and—a high power amplification ratio.

Leaving the Class A type of amplifier for the moment, let us consider the Class B type. The Class B amplifier in which the grid bias is approximately equal to that required to cut off the plate current to approximately zero when no exciting grid voltage is applied. This method of operation is shown in Fig. 3. It will be noted that the grid bias is of such a value as to bring the plate current practically to zero with no excitation (no input voltage). As a consequence no plate current flows during the negative half of the exciting voltage. Since practically only the linear portion of the characteristic is used, the plate current pulses are of essentially the same shape as that of the positive half of the input cycle. As in the case shown, since the plate current is driven upward toward the saturation point, it is usu-

[3]The ratio of a.c. output power to steady d.c. input.

ally necessary for the grid to be driven positive with respect to the cathode during part of the grid "swing." Grid current flows, therefore, and the driving source must be capable of furnishing power to supply the grid losses.

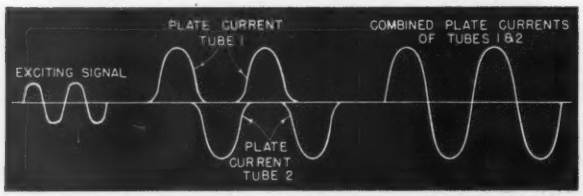


Fig. 5. Wave diagrams showing how the output of two tubes in Class B are combined to give distortionless amplification in a push pull circuit.

Since no plate current flows during a considerable portion of the cycle, it will be obvious that the Class B amplifier has a higher plate efficiency than the Class A. The Class B amplifier is characterized by medium power output, medium plate efficiency (50 to 60 per cent) and a moderate ratio of power amplification.

In Class B operation, it will be evident that even though the plate current pulses are of the same shape as the positive grid swing, such an arrangement will not give an exact reproduction of the input wave since only half cycles are present in the output. For this reason, to obtain distortionless amplification with tubes used as Class B amplifiers, it is necessary to use two tubes working alternately so that both halves of the cycle will be present in the plate circuit. Such an arrangement is shown in Fig. 4. The input current is fed to a transformer T_1 whose secondary is divided into two equal parts, with the tube grids connected to the outer terminals and the grid bias fed in at the center. Another transformer, T_2, with a similarly-divided primary, is connected to the plates of the tubes, the plate voltage being fed in at the center tap. When the input swing in the upper half of T_1 is positive, tube 1 draws plate current while tube 2 is idle; when the lower half of T_1 becomes positive, tube 2 draws plate current while tube 1 is idle. The corresponding voltages produced in the halves of the primary of T_2 combine in the secondary to produce an amplified reproduction of the input wave shape with practically no distortion. The way in which these secondary currents combine is shown in Fig. 5. A circuit using two tubes in this manner is ordinarily known as a "push-pull" arrangement; it can be used with other classes of amplifiers as well as for Class B, but in the case of the latter, for distortionless amplification it becomes a necessity.

As will be evident from Fig. 3, by designing tubes with a sufficiently high amplification factor,[4] it is possible to operate them in Class B with zero grid bias and so dispense with all bias batteries or bias resistors.[5]

[4]See Part XXIII, page 185, March, 1938.

[5]The negative potential for the grid can also be supplied from a resistor (usually called a grid leak) connected between the grid and the cathode. In this case the negative potential is a function of the grid current, the voltage representing the voltage drop produced by the grid current across this resistor. The grid potential thus is obtained by multiplying the grid current in amperes (milliamperes ÷ 1000) by the resistance in ohms. This method of securing a grid bias potential, while effective, has the disadvantage that should the excitation fail for any reason, with full plate voltage on the tube the grid bias would be lost and the plate current might rise to destructive values. In many instances therefore a combination of the two methods is used, a battery being connected in series with the resistance. Just enough battery voltage is used to keep the plate current at a safe value without excitation and the remainder is supplied by the drop across the resister.

It is for this reason that such specially designed tubes are better for Class B amplifiers than tubes not specifically designed for that purpose.

So much for Class B. Now we will consider the third general class of amplifiers, i. e. *Class C*. In a Class C amplifier, the grid is biased appreciably beyond the cut-off value so that the plate current flows for appreciably less than one-half of each cycle when an exciting grid voltage is present. The grid bias for such an amplifier is usually set at approximately twice the value required for plate current to cut off without excitation. The exciting voltage should be of sufficient amplitude to drive the plate current to the saturation point as shown in Fig. 6, which shows the principle of Class C operation. Since the grid must be driven far into the positive region to cause saturation, a considerable number of electrons are attracted to the grid at the peak of the cycle, robbing the plate of some that it would normally attract.[6] This causes the droop at the upper bend of the characteristic and causes the plate current pulse to be indented as shown. This type of

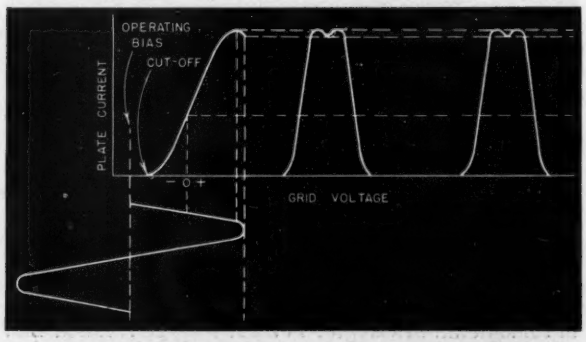


Fig. 6. Class C Amplifier Operation. With Class C, the grid bias is adjusted so far below the point of cut-off that plate current flows for only a fraction of the positive excitation cycle

amplifier operation is used exclusively for radio frequency power amplifiers. The output wave form is badly distorted but at radio frequencies this distortion is largely eliminated by the filtering or flywheel effect of the tuned output circuit.

As a matter of fact, for radio frequency amplifiers which operate into selective tuned circuits or under requirements where distortion is not an important factor, any of the foregoing classes of amplifiers may be used, either with a single tube or with a push-pull stage. For audio frequency amplifiers in which distortion is a controlling factor only the Class A amplifier permits single tube operation.

As already implied, for most industrial applications distortion is of little import. In many instances the only thing desired is the greatest change in plate current with a given grid voltage excitation. What is important is not the magnitude of the current but the magnitude of the change in current. For this reason most industrial amplifiers are biased so that the plate current without excitation is small or zero.

[6]At saturation, all of the electrons emitted by the cathode are attracted to the plate and no further increase in plate voltage will bring about a further increase in plate current. If under these conditions the grid begins to attract some of the electrons there will be just that many less reaching the plate.

Despite the fact that the "industrial" user of tubes may not have occasion to use tubes in all these different ways, still it is essential to know that they can be so used. The knowledge makes clear the reason for using certain grid bias voltages. The grid bias, it will be obvious, is very important since it determines how effectively a tube meets the requirements under which it is to operate.

These methods of using amplifiers as Class A, B or C, do not affect other considerations of amplifiers discussed in preceding chapters. The question of neutralizing, for example, is exactly the same in each case and just as necessary. So also is the matter of coupling one circuit to another. A few additional remarks about coupling, however, will not be out of place.

We have shown how the output of one amplifier may be fed into a succeeding one by means of a transformer, T_2, whose secondary is connected in the grid-cathode path of the second tube, as in Fig. 7. In this case the transformer is usually a step-up transformer, the ratio adjusted to obtain a high amplification. If amplification over a comparatively narrow range of frequencies is desired, say only at 60 or 100 cycles, the ratio of turns between the primary and secondary may be high; 10 to 1 or more, but where a wide band of frequencies must be amplified, such as in an amplifier for music or voice currents, as in a radio receiver, only a small transformer ratio can be used. This is due to the fact that it is extremely difficult to make transformers which will transform a wide range of frequencies with equal efficiency.

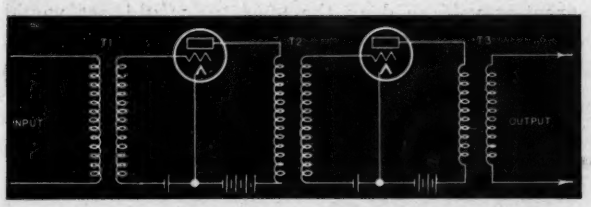


Fig. 7. Circuit diagram showing the use of interstage transformers for coupling the output of one amplifier to the input of another

Where a wide band of frequencies is to be amplified, resistance coupling can be used. In this case a high resistance is connected in the plate circuit, as shown in Fig. 8. The plate current flowing through this coupling resistance results in a voltage drop across it and it is this voltage drop that is impressed on the grid of the next tube through a small condenser. This condenser is necessary in order to prevent the plate voltage on the first tube from being impressed on the grid of the second tube.

A third method of coupling is known as impedance coupling. This is similar to the resistance method except that a choke coil or high impedance forms the coupling element. The action is very much the same as with resistance coupling, the voltage developed across the impedance being applied to the next tube. The impedance coupling method permits the use of lower plate voltages than with resistance coupling.

One thing more regarding amplifiers, and that concerns the question of voltage or power amplification. Amplifiers may be divided broadly into two general types, first, those which provide a greatly magnified reproduction of the input wave without regard to the power delivered and, second, those which are designed to deliver a relatively large amount of power to a load. In one case, the first, the amplifier is known as a voltage amplifier while in the second it is a power amplifier.

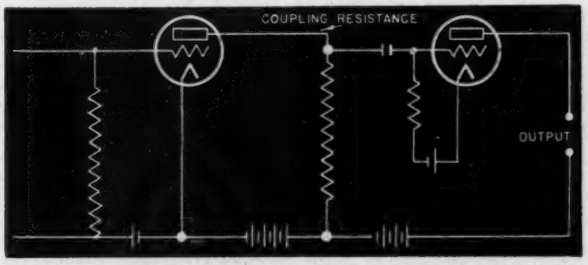


Fig. 8. Another multistage amplifier, similar to that shown in Fig. 7 but using a coupling resistance instead of a transformer

In the case of a power amplifier, a large grid voltage swing is necessary for full power output. To obtain this large grid voltage swing for the grid of such a tube it is necessary to use voltage amplifiers which greatly increase the amplitude of the impulse to be amplified as amplifiers ahead of the "power" stage. In general, the last stage of any amplifier is a power amplifier, since it is usually necessary to operate some device or circuit requiring power.

New Plant Activity

THAT ACTIVITY for the coming year will be energetic is indicated by projects planned and in work including a budget for Wisconsin Public Service Corp. of $1,675,000 for a 17,500-kw. hydro plant near Tomahawk with 32-mi., 66,000-v. transmission line to Wausau and sub-stations; also for improvements to present equipment, $115,000 for steam plants, $100,000 for hydro plants, $200,000 for transmission and $375,000 for sub-stations. Michigan Alkali Co. plans a $1,000,000 plant at Wyandotte for producing chlorine and caustic soda. Electro Metallurgical Co. division of Union Carbide and Carbon Corp. will build a $5,000,000 plant near Wilson Dam on the Tennessee River to make calcium carbide and other electric furnace products. City Electric Light and Power Dept. of Calgary, Alta., will complete its underground distribution network. City Council of Red Deer, Alta. is asking a bond issue for a $90,000 steam power plant. Contract of $170,000 has been awarded to W. A. Sheets & Sons Construction Co. for a power house and dormitories at Muscatatuck, Ind. colony for feeble minded. Elkhorn Construction Co. has a $192,864 contract for 116 mi. of rural transmission at Kearney, Neb. Grant of $36,000 has been made by REA to Lower Valley Power & Light Co., Freedom, Wyo. to construct a generating plant and transmission lines. In Michigan, Dow Chemical Co. plans further expansion of its power plant and Consumers Power Co. is planning two plants on the Saginaw and Kalamazoo Rivers. Welland, Ont. Hydroelectric Commission has authorized construction of a new $85,000 substation. Cleveland (Ohio) Illuminating Co. will add a 50,000-kw. turbine-generating unit to its Ashtabula plant. Myerstown, Pa. Council is to let contract for a municipal power plant, and Olean, N. Y. Council is investigating advisability of building a municipal plant.

Testing High Voltage Insulators in The Field

AN INTERESTING and useful testing device for live line testing, in the field, of the individual porcelain insulators was developed recently by Roller-Smith Co. of New York. The complete outfit consists of a high resistance bakelite insulated test stick made in three insulator sections and a handle section which screw together, an indicating instrument, a ground prod and the necessary connecting cable and connectors.

The method of using the stick is very simple. The three insulator sections of the stick and handle section, in which one end of the cable is fastened, are screwed together. The other end of the cable is plugged into the indicating instrument and the sharp pointed prod on which the instrument is mounted is shoved into the ground. The ground resistance is negligible as it may be several hundred ohms and still make no difference in the indication of the instrument.

After the device is set up in this manner it is necessary to touch the live line directly above the first insulator in the string and adjust the pointer on the instrument by turning the rheostat in the side of the case until the pointer reads exactly on full scale. This reading represents 100 per cent and is "live line" voltage.

By touching the metal collar between each insulator, progressively from live end to ground end of the string, a uniform gradient of line to ground voltage is secured. Live line

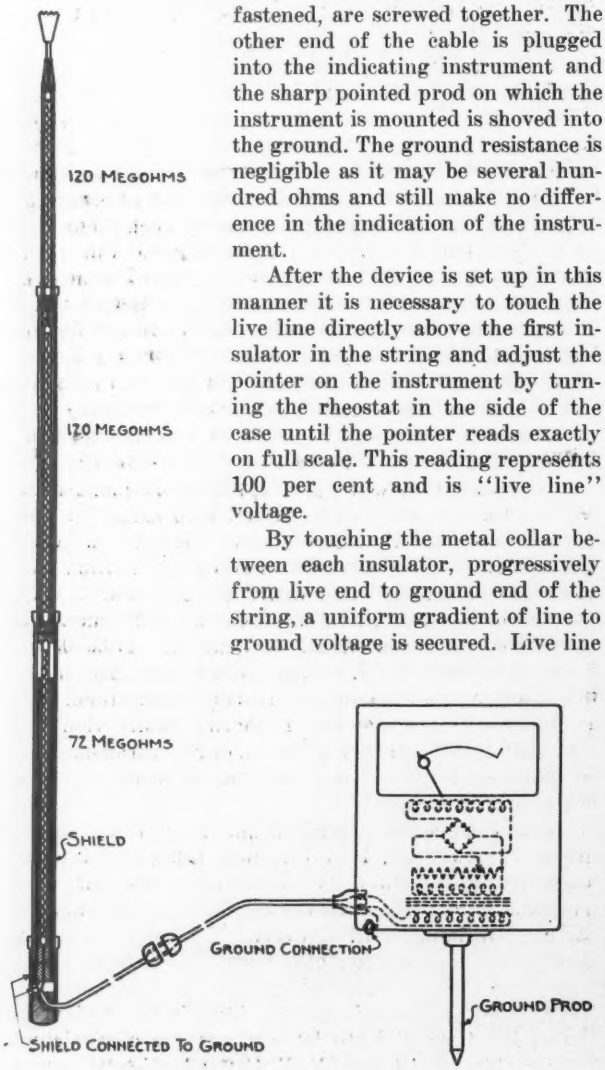


Fig. 1. Details of the test equipment

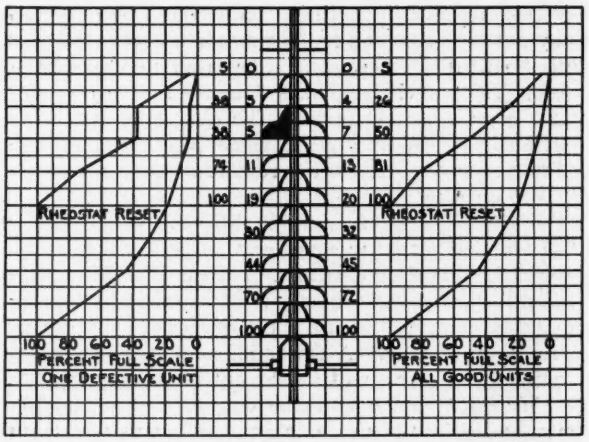


Fig. 2. Curves showing potential gradients across insulator string as disclosed by the tester

end will be 100 per cent and the ground end will be zero.

The construction of this device is shown in the accompanying diagram. Each of the three insulator sections of the stick consists of a Bakelite tube enclosing another Bakelite tube, the inner tube being separated from the outer tube by a considerable air space. Each inner tube encloses a specially developed high voltage resistor. This stick can be handled with absolute safety as there is 320 megohms total resistance in the three sections. Figuring the stick resistance at 320 megohms and the resistance of the human body at 20,000 ohms, even when used on 100,000 v. the greatest voltage drop the operator would get would be about 8.5 v. at the end of the cable. Even though the ground connection is broken no harm results to the operator. This has been tried repeatedly on 132,000

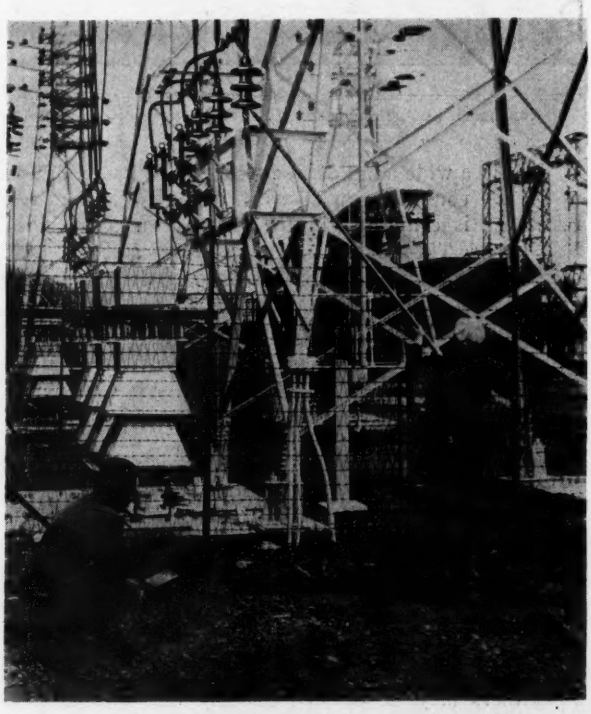


Fig. 3. Testing insulators on the equipment in a high voltage sub-station

v. lines: the stick is held in the bare hands, the tip touched to the live line and the cable disconnected. The operator feels a slight static charge. As a matter of fact, the insulation is about the same as that of the wood stick used to open the disconnects.

In operation, the measurements taken are percentages of total voltage from line to ground. The device does not measure voltage as such. With the instrument grounded the tip of the stick is touched to the live line and the rheostat adjusted until the instrument reads 100 per cent or full scale.

The tip is next touched to the metal cap of each insulator in succession and the instrument reading for each insulator recorded. If, part way down the string, two successive readings are alike, the porcelain between the points of these readings is defective. This may be checked and the difference magnified by returning to a point above the defective insulator and readjusting the rheostat until the instrument reads 100 per cent at that point. The results of such a test are shown in Fig. 2. Reference to this curve will show the degree of precision with which the tester locates the defective units in the string. The left and right curves were made on the same insulator string except that one punctured unit was substituted in the left curve. The unit record from the ground was chosen because across this unit usually occurs the minimum potential drop and this is the most difficult unit to test.

Capacitors Serve a Double Purpose

By A. L. Atherton, Engineering Division Westinghouse Elec. & Mfg. Co.

DIESEL-DRIVEN GENERATORS operated by the Electric Light Department of a New England town to supply local residential and industrial power and neighboring towns have gotten into trouble occasionally due to lightning. The generators are connected directly to overhead lines radiating from the station in such a way as to be subject to lightning disturbances for all storms in the near vicinity. The circuits, operating at 2300 v. delta, are brought into a tower structure just outside the station building and from there through entrance bushings into the bus structure just inside the building. Three generators are parallel to the bus in various numbers and combinations dependent on the load.

On several occasions during the past few years, winding failures have occurred during thunder storms. These have involved only one generator, the oldest of the three, in which the insulation may be expected to be somewhat less capable of withstanding abnormal stresses due partly to earlier design and partly to greater age.

After each failure, some investigation has been made and generally some improvement worked out for the protective system. Finally, line type arresters are installed at a distance of about 1500 ft. from the station on each circuit; the second set of arresters is installed on each circuit at a distance of about 500 ft. from the station. A third set of arresters is installed on the tower structure just outside the station; and a capacitor unit is connected from each line to ground at the bus within the station. All the equipment has been well chosen and carefully installed. Grounds are well made and known by measurement to be of low resistance. Connections from the circuits through the arresters to ground are direct and short.

In spite of these measures, an additional failure occurred during this summer, resulting in the burn-out of several coils of the vulnerable generator. The indications are clearly that the case is one combining severe exposure with probable unusual susceptibility to damage, thus requiring unusual measures for protection.

The arrangement of circuits, the location of the faults, and the condition of the insulation adjacent to the faults, all indicated the probability that, though the failures included punctures to ground, the initial fault was probably established between conductors.

During the time immediately prior to this last failure, load requirements had been growing at an unusual rate, resulting in the anticipated need, without much delay, of some means of relieving the generator load. Since the power factor was low, consideration was given to securing this relief from the effects of abnormally steep wave-front voltages held down in magnitude by unusually complete lightning arrester protection with arrester units of the most modern type and with the best "protective ratio" available, approximately 2 to 1. In spite of this reduction to as low a point as possible in the magnitude of voltage, insulation failures still occurred. In spite of the sloping effect of the installed protective capacitor working through the line impedance out to the arresters installed at a distance from the station, failures occurred and apparently between conductors.

It was decided that the best expedient to adopt would be to install a power factor correcting capacitor on the bus with the units arranged in wye, and with the good ground connection from the neutral point. The 150 kv-a. of corrective capacity, determined by the power factor requirements, would give something like fifty times as much capacity for sloping the incoming wave as has been found by theory and experiment to be feasible and effective in similar installations. In addition to the unusually great provision for preventing abrupt voltage rises on the machine terminals, the large capacity to ground will serve in itself to hold down the voltage in magnitude to a very material extent.

Naturally, the only proof of adequacy of this measure will be continued service, without failure, over some years. The improvement in protection is, however, unquestionable and is available without investment except for the need for a ground connection.

EMERSON wrote "A man *is* what he is thinking." Why spend much time on newspaper stories of murders, divorces and the like? Good business and technical periodicals and good literature are waiting.

Electronic Smoke Indicator Improves Operation at Hiram Walker Plant

System installed originally only to give warning proves of value in controlling combustion conditions in large Peoria power plant.

By

R. P. Pfeiffer

Test Engineer
Hiram Walker & Sons, Inc.
Peoria, Illinois

AT THE "WORLD'S LARGEST DISTILLERY"—the huge new plant of Hiram Walker Sons, Inc., at Peoria, Ill.—steam for power and processing needs is supplied from two 1,379-hp. bent-tube boilers, equipped with superheaters and water walls, and fired with pulverized coal. To meet the increased steam demands resulting from recent developments in processing by-products, these two boilers are now operated simultaneously at 400 to 500 per cent of rating a large part of the time. Sudden changes in the processing load occur quite frequently, which means that adjustment of burners and other factors in combustion control demand unusual care if a serious smoke problem is to be avoided.

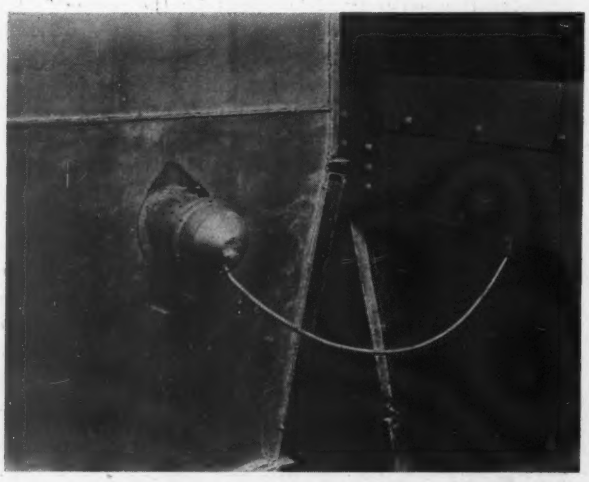


Fig. 1. Special light source mounted in outlet flue of boiler. Note holes which permit inrush of air which cools lamp and keeps lens clean

A modern system of automatic combustion control, along with CO_2 indicators and draft gages, aid the fireman in maintaining peak efficiency. However, in view of the rapidity with which combustion conditions can change, this control cannot go the whole way in eliminating periods when considerable smoke is likely to come from the stack. For many plants, a "couple-of-minutes" smoke now and then might be relatively unobjectionable, but not at Hiram Walker & Sons, where cleanliness and public good-will are twin objectives at all times.

Under these circumstances, we were anxious to find some practical means of maintaining a continuous, minute-by-minute check-up on smoke conditions in the flue leading from each boiler to the stack. After some investigation, we decided to install one of the Weston smoke alarm units, in which a Photronic "electric eye" is mounted in the flue directly opposite a small light source. This was somewhat of a test case, as previous installations brought to our attention were on other types of fuel, and we realized that flue conditions with pulverized coal as a fuel would be difficult to meet. Later, after the first unit had proved successful, a similar unit was put in operation on the flue from the second boiler.

Fig. 2. The Photronic Cell is mounted in this protective housing. The visor is mounted entirely clear of the breeching and can be tilted upward for cleaning

Details of the Installation

The complete installation, consisting of the light source, the photocell housing and relay cabinet was relatively simple: The specially designed spotlight, equipped with a double contact automobile headlamp bulb, was mounted on a section of 4-in. pipe about 10 in. long, projecting into the outlet flue of the boiler (Fig. 1). A row of ⅛ in. holes was drilled in the pipe to permit an inrush of outside air, which tends to cool the spotlight and keep the lens clean. The spotlight itself is equipped with a rhodium plated reflector, so arranged that a narrow light beam can be focused on the photocell mounted directly across the duct. The lamp operates from 6 v. step-down transformer on the

regular 110-v. a.c. line, a rheostat in the low-voltage circuit permitting adjustment to maintain a uniform light output. The photronic cell is enclosed in a protective housing with a double glass face. This was so mounted that the visor is entirely clear of the breeching (Fig. 2). Thus, there is no metallic heat conduction to the cell, and the visor can be easily tilted upward for cleaning.

The operating principle of the relay unit controlled by the photocell is generally familiar: With a clear stack, the photocell generates enough current (about 50 microamperes) to hold open a sensitive relay on the control panel. In our installation, it also actuates a larger, horizontal-type microammeter with a 5 in. scale, calibrated in terms of smoke density (Fig. 3). As smoke cuts the intensity of the light beam, the current generated by the cell is decreased until finally, at some pre-established level of smoke density, the relay

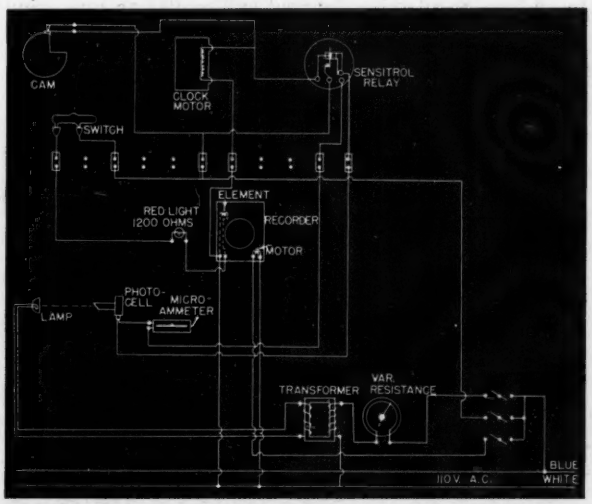


Fig. 3. Diagram of connections of smoke indicator and recorder

contact closes. This establishes a second electric circuit which operates a small motor on the relay panel. A cam turned by this motor tilts a mercury switch, which turns on an alarm light and, in our installation, also operates a Bristol recorder to show that a condition of excess smoke exists. After a 1-minute cycle, a second cam opens the relay for a "re-check" on smoke conditions. If excess smoke still exists, the operation is repeated, the warning light again flashes on, and another mark is made on the recorder. If the situation has been corrected, the unit simply remains on guard once more. Of course, the microammeter in the circuit follows the smoke-density conditions continuously, whether above or below the "alarm" level.

System Serves as a Means of Controlling Combustion Conditions

Originally, we considered the installation of these units simply for their warning value, to enable the fireman to detect and correct the periods of smoking which occurred when demands for process steam were suddenly decreased. Now, however, after several months of operation, they seem to be coming even more valuable to the fireman as a means of control, for the smoke-density indicator has been found to give the

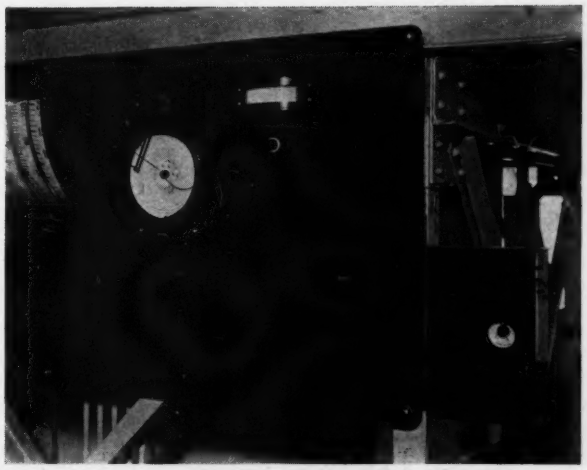


Fig. 4. At the lower right in this picture is shown the panel box containing the sensitive relay system which is actuated by the photocell. In the center is the smoke density indicator and warning signal while at the left center is the smoke interval recorder

firemen a better indication of combustion conditions than actual observation of the furnace.

By watching the smoke-density indicator, the fireman is frequently able to note and act on the initial change from "clear" to "haze" in the flue, and make the necessary fuel and air-flow adjustments to anticipate greater variation in combustion conditions and to forestall any serious amount of smoke. We certainly did not expect that installation of the smoke-alarm unit on one of our boilers would show up an erratic condition in the feeder control for one of the coal pulverizers which we did not know existed. Yet that is what actually took place, and as a result we were able to correct the condition quickly and positively.

In respect to reliability and continuity of service, the alarm system has been in constant operation now for a number of months, and the only necessary maintenance has been periodic cleaning of the glass on the photocell and spotlight, and the renewal of the inexpensive head lamp bulb in the spotlight.

Finally, while it is difficult to place any monetary value on the impressions created in the minds of employees, visitors and residents of nearby areas, we feel convinced that the increased good-will created by a clean stack and smokeless plant surroundings more than compensates for the cost of the smoke alarm equipment and its installation. It carries out the tradition of cleanliness and orderliness, inside and out, that is a major objective at every Hiram Walker & Sons plant.

The amount of gas used in industry and commerce has been at an all time peak for two years and considerably above the pre-depression years. According to Hale A. Clark, Chairman of the Industrial Gas Section, American Gas Association figures show that for the year 1937, the gas utilities sold 1,090,310,000,000 cu. ft. of industrial and commercial gas. These figures, which include both manufactured and natural gas, disclose a gain of 10 per cent over the preceding 12 month period or double the rate of increase in industrial production and commercial activity as reported by the Federal Reserve Bank.

Grand Trunk Rebuilds Boiler Plant

Grand Trunk Western R. R. Co., at Battle Creek, Mich., replaces Hand fired vertical boilers by modern stoker fired, forced draft units in a well arranged and well lighted plant

By GEO. E. MURRAY

Electrical & Mechanical Engineer

TO MEET the increasing and diversified demands of modern shop methods, the Grand Trunk Western Railroad Co. rebuilt, in 1937, the boiler plant serving its large locomotive repair shops at Battle Creek, Mich. This up-to-date plant now supplies steam for heating the entire locomotive repair shops and offices, steaming up rebuilt locomotives, operating steam hammers, testing air pumps, operating boiler room auxiliaries and miscellaneous units around the shops. A 200-kw. engine generator set is installed in the engine room for emergency service but electric power is normally purchased from the Consumers Power Co., the d.c. load being taken care of by a 200-kw. rotary converter. Direct steaming of locomotives, at the round house about a mile from the repair shops, is taken care of by a separate boiler room with three chain grate boilers rated at 238 hp. each.

The new equipment was installed in space provided by removing four old hand fired vertical boilers and utilizing the old coal bin which ran the length of the boiler room under a spur track as shown by the drawing on the next page. This old coal bin is now divided into three sections: a dead storage at each end for emergency use; and a center section with a track hopper and complete Link-Belt handling and conveying system.

Coal Weights Checked

From the track hopper coal is delivered to a bucket elevator by a feeder and discharged to an elevated cylindrical coal hopper holding a 24 hr. supply. The elevator and feeder are driven by a 5-hp., 1160 r.p.m., 440 v. motor through a Link-Belt speed reducer. From this hopper coal is distributed to the stoker hoppers by a weigh larry. The larry readings used in conjunction with the Republic flow meter readings give a good check on boiler performance.

At present rail and river screenings from Bellaire, O., with a heat content of about 13,000 B.t.u. is being burned. The volatile runs around 37.90 per cent; fixed carbon 51.95 per cent and ash about 10.15 per cent. Sulphur by separate determination is about 4.32 per cent.

Two boilers are installed, as shown in the plan view on the next page, with an auxiliary bay between them. A Union 10 by 7 by 10 in. boiler feed pump is located on the ground floor on either side of the bay and an open feedwater heater is installed directly above. A passage way between the pumps leads to the engine room, and, the overhead coal hopper directly in front of the auxiliary bay divides the boiler aisle into two parts but is located so that the weigh larry can pass to service either boiler.

Boilers are both 500 hp., Union Type N, set with the mud drums 12 ft. above the floor and fired by Firite stokers with sufficient grate area to give 200 per cent maximum rating. Each boiler has Detrick air cooled walls, a Copes feedwater regulator, Diamond soot-blowers, Shallcross combustion control and a Buffalo Type CL, size 6 forced draft fan. Fans are driven by 20-hp., 865 r.p.m., 440 v. motors and stokers by 1½ hp., 1160 r.p.m., 440 v. motors through Reeves variable speed drives. Ash is handled by a United steam jet conveyor to an outside tile silo elevated sufficiently to dump by gravity to hopper bottom cars.

Lighting

Although the plant was built primarily to reduce costs through more efficient operation, the soundness of which has been demonstrated during the present heating season, sight was not lost of the need for operating convenience and safety. The lighting, designed by J. H. W. Conklin of the Consumers Power Co. and described in greater detail later in this issue, is accomplished through the use of high bay and low bay equipment, giving good general intensity. Points of particular interest are lighted to a higher intensity by supplementary units specifically chosen for each particular location. Thus boiler gages are lighted for quick and easy readability, while ash pits are lighted with supplementary units because of the impossibility of making the general lighting penetrate duct work and other obstructions.

The boiler plant itself was designed under the supervision of the author with R. R. McIntosh in direct charge of design and construction. A. W. Everett is chief engineer of the plant.

Photo, Hoffman Combustion Engineering Co.

The firing aisle of the new plant. Coal handling and coal storage facilities are just to the left of the picture and auxiliaries are grouped in a bay between the two boilers. A plan and cross-section of the plant is shown in the next article

Boiler Room Lighting

By J. H. W. CONKLIN

Lighting Engineer
Consumers Power Co.
Battle Creek, Mich.

POWER PLANT LIGHTING in general, is badly handled and the boiler room in particular seems to be the unwanted stepchild. But in the new Grand Trunk boiler room the lighting is everything that the most rabid Better-Light-Better-Sighter could ask for. Here the direct, compact arrangement, plenty of space but none wasted; walkways, ladders and stairs, solid and substantial, located where needed; valves and equipment accessible, indicate that the designers knew their jobs. They also knew that modern lighting is something for a specialist. They purchase electric power and so turned to the Consumers Power Co. and J. H. W. Conklin undertook the job.

We have no hesitancy in saying that the result is the finest boiler room lighting, industrial or utility, that the editors have seen and they see many in the course of a year. After some little persuasion Mr. Conklin consented to write an article which quite comes up to the standard set by the job itself.

Did the Battle Creek job cost much? You'll be surprised when you read how little it actually cost, less than one moderately serious lost time accident.

WHEN THE Grand Trunk Railway decided to modernize the power house boiler room at the Battle Creek Shops, it was felt that modernization of the lighting was an important part of the problem. Accordingly the railroad called on the Lighting Department of the Consumers Power Co. for assistance, with the idea that the problem should be considered from all angles to get the best possible results. Details of the boiler installation have been briefly explained in the preceeding article so that this article considers the modernization problem entirely from the lighting angle.

Fundamentally there were several things to be decided before details could be worked out. Light intensity necessary for general operation had to be decided upon. There must be sufficient light at all points to prevent accidents and promote neatness of operation, while, at the so-called critical points of operation, more particularly gages and meters, the illumination must be such as to give the greatest speed and efficiency in operation. An intensity of approximately 10 ft. candles was decided upon for general illumination. This is sufficient for the operators yet provides a satisfactory ratio of illumination to eliminate temporary difficulty of vision on entering or leaving the boiler room. Obviously 10 ft. candles is not sufficient for dial faces and for gage reading, so local lighting of 40 ft. candles or better was provided at these points.

Once the approximate intensities were decided upon, the question of how to accomplish those results without glare, either direct or reflected, had to be answered. Approximate intensities rather than footcandles to four decimals, are mentioned because, of the difficulty, all too common in industry, of determining hanging heights of units to fractions of an inch; of foretelling the amount of dust in the air and on the unit; and of prophesying the maintenance periods for the units, or any of the numberless things effecting "operating efficiency."

Boiler rooms being designed primarily for efficiency of operation rather than beauty of skyline, and, for conservation of space rather than broad vistas, the particular problem of unit location presented most difficulties. As may be seen by the accompanying floor plan and elevation, the coal bunker and weigh larry occupy, either continuously or temporarily, the area before and between the boilers. Light for the boiler gages, located just above the stoker supply bunkers, had to avoid all obstructions as well as come from an angle which would eliminate glare on the gage faces. Two units therefore placed on the wall facing the boilers, 8 ft. from the floor on 11 ft. centers on the center line of each boiler.

Thus spacing is such that, despite the position of the weigh larry, at least one unit is focused on the gages at all time, and, the angle of the light beam from units mounted at 8 ft. onto the gages is such that reflected glare is away from the operator's eyes. The equipment used was a local lighting unit (1)[1] with a 150 watt Mazda lamp. This type of unit was chosen primarily because of the concentric louvres and lens. The beam is well confined, glare is eliminated and the glass face collects the dirt, making maintenance easier than with an open type.

Ash Pits

Ash pits presented a problem similar to that of the boiler gages. Here the possible obstruction is workmen rather than equipment, and, the need for high intensities is not present. It was felt that intensities in the order of 15 ft. candles were adequate, but illumination should come from two sources. Space limitations are also present as may be seen from the drawing. The walkway limits headroom, and the units used must be as close to the wall as possible to prevent interference with work and damage to the units. As a result symmetrical angle reflectors (2) of porcelain enameled steel were selected. These were hung 5 ft. 6 in. above the highest floor level of the ashpit on 11 ft. centers and again centered on each boiler. In these units 100 watt Mazda lamps were used. The effect minimizes the shadow of the workman himself (shadows were not entirely eliminated but those remaining were not dark enough to cause discomfort or inconvenience) and gives the best possible conditions for maintaining such a degree of cleanliness as is possible in such a location.

General lighting, which had been set at some 10 ft. candles was not exceedingly hard to lay out. The floor area in front of the two boilers, the alley-ways at the sides of the boilers and the area in which the boiler feed pumps are placed obviously need light. So-called low bay (3) units were decided upon for the areas beside the boilers. These units, mounted as shown in the drawing directly beneath the walkways and equipped with 300

[1]Figures in parenthesis refer to lighting unit numbers in the table.

watt Mazda lamps, were chosen with efficiency, economy, and ease of maintenance in mind. There was also another point which had a bearing on the choice of these units, safety. Both the Grand Trunk Western and the Utility are disciples in the cause of Safety, and as far as can be determined, there is no hazard in this installation.

Since there were no walkways, large beams, etc., in front of the boilers and as the coal bunker occupies a prominent place between the boilers, high bay (4) units were decided upon for the boiler aisle. Here this type of unit serves a double purpose. The area directly before the boilers is illuminated to the desired intensity, while the area beneath the coal bunker is lighted without a great loss of light on the sides of the equipment. The distribution angle of the unit accounts for this condition. The units themselves are mounted about 20 ft. from the floor and equipped with 500 watt Mazda lamps.

Auxiliary Bay

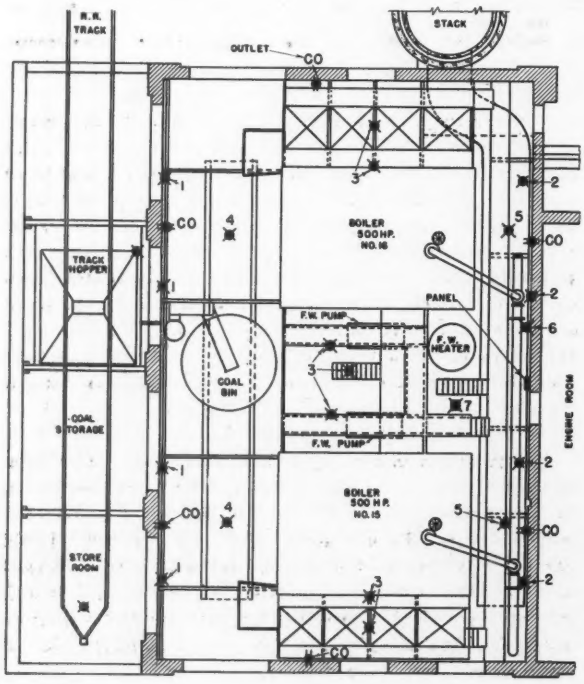
Lighting between the boilers was still another problem. On the main floor are located boiler feed pumps, on a higher level is the feed water heater and from there steps lead to a higher walkway servicing the rear of the boilers. The problem was to light this area, composed of several levels, for general operation and safety. The boiler room floor level was taken care of by two low bay units (3) with 300 watt lamps, one under a walkway on each side of the area over the pumps. At a height of some 7 ft. above the walkways, but within reach of a man on the walkway, another low bay unit equipped with a 500 watt lamp was located (3) with a 45 deg. distribution from the vertical and centered as nearly as possible on the stairway to the waterheater platform. This gives an acceptable intensity of light on the platform and stairs to the boiler tops. At the same time it increases, above 10 ft. candles, the illumination at the pumps and the passage to the turbine room which is now used only for conversion of a. c. to d. c. energy.

Areas above the walkways and on top of the boilers is not an area of critical seeing except from the angle of safety. A lower intensity of light could be used if it were not for the possibility of accident from too great a differential in lighting intensities between this and other various parts of the boiler room. For this reason the intensity had to be held up to some extent. One low bay unit (3) to give the widest distribution, was located above the outside edge of each boiler 12 ft. above the walkway. Since the unit located between the boilers above the walkways would help prevent accidents there, these two units adequately illuminated the boiler tops and walkways on the sides and in the rear of the boilers. Two hundred watt lamps were used in these units.

With the foregoing explanation one might think that the general lighting had been adequately taken care of, but there were still several bad points. The walkways, over the ashpits, were dark. Here there was but 5 ft. head room, space was at a premium and light was of interest primarily from an accident prevention standpoint. A lighting unit of the least possible overall height was necessary, so a shallow dome reflector (5) of porcelain enamel steel with a 60 watt lamp was recommended. One unit was located on the center line of each boiler and the attendant walkway as high as the duct work would permit.

One ashpit ladder was also a danger spot, for it was shielded from all lighting units by structural members or equipment. This situation was taken care of by a single deep bowl (6) unit housing a 60 watt Mazda lamp mounted on a conduit bracket and wall flange 7 ft. above the floor level and at the head of the ladder so as to adequately illuminate the steps.

Finally there was the main passage from the boiler room to the turbine room. This passes under the balcony of the water heater, has only 7 ft. headroom and was exceedingly dark. Obviously a passage in constant use could not be lighted by a shallow bowl reflector with its attendant glare and blinding effect. The turbine room with excellent daylight illumination is very bright, and



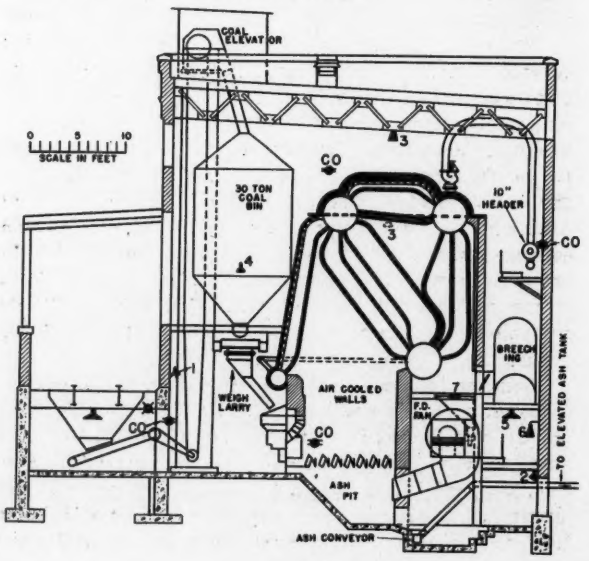


Fig. 1. Plan (left) and cross section (below) of the new Grand Trunk boiler room. The location of convenience outlets and lighting units are indicated on the drawing and the latter are identified by numbers used throughout the text and in the table. The seven different units are shown in Fig. 2

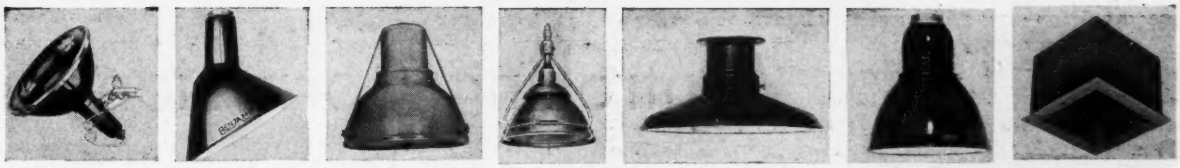


Fig. 2. Seven types of lighting units are used in the boiler room. The location of each is indicated on Fig. 1 by number and identified in the table. The seven are, from left to right: 1, local lighting units with 150 w. lamps; 2, symmetrical angle reflectors with 100 w. lamps; 3, low bay units with 300 w. and 500 w. lamps; 4, high bay units with 500 w. lamps; 5, shallow dome reflectors with 60 w. lamps; 6, deep bowl unit with 60 w. lamp; 7, lens box unit with 200 w. lamp

when entering the boiler room the danger of momentary blindness because of differences in lighting intensities was an important factor. It was decided to install a lens (7) box with a 200 watt lamp between crossmembers of the overhead walkway so as to give maximum headroom combined with sufficient light to preclude undesirable ratios of intensities between that point and the turbine room on a bright day.

The room under the track hopper, housing the coal feeder requires little light because of the nature of the work done there and the infrequent visits. The room is small with a low ceiling, so a unit mounted at a height of some 7 ft. on the wall near the door gives sufficient light for avoiding the equipment on the rare occasions a workman uses the room. The tool storage room is in the same general category, but the floor area is less cluttered with equipment. Here a shallow bowl reflector, mounted on the ceiling in the center of the room, gives enough light for the identification of large tools. The lighting for each of these is controlled by a switch located in the boiler room adjacent to the door of the room.

When the general lighting intensity was set at 10 ft. candles it was known that this would be insufficient for any repair or overhaul work. Obviously, however, it was not economical to light the boiler room at all times to an intensity sufficient for repair work, also it was probable that electric drills, etc., might be necessary as an aid to repair work, so convenience outlets were located where shown in the drawing. The outlets were placed 4 ft. from the floor of the boiler room or the ashpit as the location demanded, and where walkways ran above these locations additional outlets were placed 4 ft. above these walkways. This system permitted the use of trouble lamps on extension cords as well as small portable equipment such as drills, grinders, etc., if and when they should be needed.

Wiring presented no particular difficulties. It was decided to make the boiler room lighting installation completely separate from the lighting system throughout the rest of the plant so that as modernization took place elsewhere in the building this portion of the installation need not be disturbed. As a result a 16 circuit, 100 amp. 125-250 v. distribution panel was located where shown on the diagram near the turbine room door. This panel was equipped with circuit breakers of 15 amp. capacity in the branches as well as a main switch. This was also of the circuit breaker type, which could, when desired, isolate the boiler room completely from the rest of the lighting system.

Number fourteen wire was used on all the short circuits while No. 12 was used to supply the lighting units on the wall in front of the boilers and all convenience outlet circuits. None of the circuits were loaded to more than 50 per cent of capacity so that voltage drop was eliminated to a great extent, and provision made for more light if it should be considered advisable in the future. The switching of the circuits was so arranged that either part of the installation or the whole thing might be used depending upon whether one or both boilers were in use.

Cost of this installation was not great but may not be typical because of the conditions under which it was put in. The wiring was not put in on a contract basis. Shop electricians did the work and did it between interruptions to take care of necessary maintenance work with the result that labor time ran higher than it might have otherwise. In spite of this, the total cost of the installation of this lighting system on a materials and labor basis ran approximately $700.00. This figure was composed of wiring materials to the amount of $410 with the distribution panel cost of approximately $200 being the largest item, fixtures to the amount of $120 and labor to the approximate amount of $170. These figures do not include shop overhead amount which will vary in different plants and may be substituted in applying these figures to any particular location to fit the conditions in that plant.

Lighting units used in the Grand Trunk boiler room. Figures preceding each unit refer to the number used in parenthesis throughout the article and indicated on the drawing. The various units are illustrated in Fig. 2, identified by the same numbers

1. Benjamin Electric Mfg. Co., Intensifier No. 5604. Alternate: The Miller Co., Sup-Lite No. PSAS150.
2. Benjamin No. 5542. Alternate: Miller No. REL-100; Westinghouse No. 343513.
3. Holophane Co., Inc., No. 685AL. Alternates: Miller No. REDD-500; Benjamin No. 26561; Westinghouse No. 343735.
4. Holophane No. 681AL. Alternate: Miller, RAS-500.
5. Benjamin No. 26822. Alternate: Miller, RED-100; Westinghouse No. 343542.
6. Benjamin No. 26658. Alternate: Miller, REB-100; Westinghouse No. 343776.
7. Holophane No. H774-F1.

The lighting installation at the Grand Trunk Western's Battle Creek boiler room has been gone into in some detail because the plant itself is a typical example of good power plant layout and is interesting primarily from that standpoint. However, any attempt to generalize on the lighting installations of boiler rooms as a whole is exceedingly difficult, for each installation presents its individual problems. Even where the physical construction of two plants is similar there will be problems peculiar to each which must be solved not with generalities but by specific means to give adequate results. Consequently each lighting installation becomes to all intents and purposes a tailor made job.

There are, however, certain fundamentals which must enter into every satisfactory layout. The light used must be adequate in quantity and of good quality, that is without glare. To accomplish these results light should come on to the work from several angles to eliminate shadows, the lamps used should be of sufficient size to give the required quantity of light, and the fixtures themselves should be selected with cost, efficiency, ease of maintenance and durability in mind.

Fig. 1. A typical case of channelling in a condensate return line. Pipe line corrosion is particularly hard to combat because it is difficult to detect until it has reached the stage where replacement of the lines is necessary

Controlling Corrosion in Steam and Return Lines

An old problem yields to a new process in which corrosion in steam systems is controlled by maintaining alkalinity in the steam and condensate. This new development is based on the application of suitable amines to steam systems

By M. E. Dreyfus,

Western Chemical Co., Kansas City, Mo.

CORROSION in steam and condensate return lines has always been a difficult and expensive problem. Filling up of lines with rust deposit, grooving and pitting, development of leaks, complete perforation—all of these troubles result from uncontrolled corrosion and lead to reduced efficiency of operation and eventually costly replacements.

It may take years or only a relatively short while for these symptoms to appear, according to whether the corrosion is general or localized. The chief hazard is that so often the damage is concealed until too late for any remedy except replacement. Until leaks actually develop, the only evidence that corrosion is progressing may be the presence of rust in the condensate. Such an indication should never be ignored.

According to the generally accepted electro-chemical theory, corrosion is promoted by an acid environment. While oxygen plays an essential part, its effect is not primary but secondary. The first reaction, according to this theory, takes place between the iron and the water, the iron going into solution and a film of hydrogen forming on the metal. The action of the oxygen is to combine with and remove this hydrogen film, "depolarizing" it so that more hydrogen can "plate out" and allow the corrosion to proceed.

It is both in accordance with the theory as well as an established fact, that in acid solution the hydrogen plates out most rapidly and the corrosion is most rapid. In a neutral solution, corrosion is slower. In alkaline solution, it is the least active of all. Consequently, with the amount of oxygen present a constant factor, corrosion can be retarded in an alkaline solution.

It is true that there is always some oxygen present in steam and return lines. While de-aeration followed by the use of a reducing agent in the boiler water will lower oxygen in the boiler itself to a minimum, elimination of oxygen in the lines is not completely secured due to infiltering air.

The agent which creates the acidity in a steam system is carbon dioxide, CO_2. Carbon dioxide is ordinarily present in the lines and originates as the free gas dissolved in the feedwater, from the decomposition of bicarbonates naturally present in most water supplies and from infiltering air. It is, of course, common practice to maintain an alkaline condition in the boiler water, and thereby protect the boiler metal below the water line. Such treatment, however, does not reach the other parts of the steam system, including the boiler above the water line, steam lines, traps, radiators, and condensate return lines. In those zones oxygen in the acid environment created by CO_2 permits corrosion to proceed rapidly.

By means of a process covered by a recently issued patent, this problem can now be met in an effective and practical way. The patent covers the application of certain amines to steam systems, and the product now available for use under this process carries the registered trade name Coravol.

Amines are organic substances which are alkaline in nature and therefore, have the property of combining with and neutralizing acids. The amines covered by and used in the new process are further characterized by their solubility in water and their temperature range for vaporization and condensation.

They are introduced as a liquid, dissolve in the boiler water, volatilize with the steam, condense with the steam, form a solution in the condensate, and return with it to the boiler. They do not collect or remain in any one zone, but circulate through all, maintaining an alkaline condition from the boiler through the lines and system back to the boiler, with CO_2 neutralized, absorbed, and removed. The entire system is protected against the deteriorative effects of acidity, with corrosion greatly retarded even in the presence of oxygen.

This treatment reaches those parts of the steam system not accessible to boiler feedwater treatment and its use does not replace standard methods of treating the boiler water itself. Proper corrective treatment for the protection of the boiler metal below the water line is as necessary as ever, for to attempt to accomplish this by means of Coravol alone would be an uneconomical and inefficient procedure for sufficient would then have to be used to neutralize all of the carbon

dioxide in the boiler water, before there would be an excess, free to circulate throughout the system.

By treating the boiler water in the regular way to maintain alkalinity, corrosion is prevented below the water line, and the Coravol is maintained in its active, alkaline, and volatile state, free to vaporize with the steam. After it absorbs CO_2 throughout the lines and system and returns to the boiler with the condensate, contact with the alkaline boiler water again frees it for recirculation.

It is this continuous circulating action which contributes to economical use. After the desired alkalinity in the system has been built up by initial dosages, only enough need be added from time to time to replace that lost from the system. Naturally, economy in use is greatest in plants with relatively low percentages of make-up water.

The preliminary survey of a steam plant with a view to the application of this treatment takes account of those factors of size, design, and operation, which determine the probable dosage required. These factors include: total daily evaporation; amount of make-up water; pressure carried; chemical character of make-up water; how condensate enters the boiler; purpose for which steam is used; sources of loss of steam and condensate; length and size of lines; and condition of lines.

In actual use, however, the dosage is not determined by an estimate based on these factors but is controlled by a direct test, using a simple testing set, shown by Fig. 2, especially designed and furnished for the purpose. This testing set includes a special testing flask, a 150 c.c. Pyrex beaker, a bottle of standard sulphuric acid solution with dropper, and a bottle of phenolphthalein indicator solution.

Fig. 2. Control of alkalinity by this treatment is made easy by this simple test kit and a test procedure which requires no knowledge of chemistry

Since the treatment creates and maintains an alkaline condition in the steam and condensate, the test for the degree of treatment is the alkalinity of the condensate itself. In making this test, a sample of the condensate to be tested is caught in the beaker. The flask is rinsed out with a small amount of the condensate and drained. Four drops of the phenolphthalein indicator are put into the empty flask and sample is poured in up to the lowest, or 50 c.c. mark.

The contents of the flask are mixed thoroughly by placing the thumb over the mouth of the flask and shaking vigorously, reversing several times. A permanent pink color shows the presence of Coravol in the condensate.

Now some of the standard sulphuric acid solution is dropped into the flask, stopping to shake as the contents of the flask reaches each successive graduation in the neck. The amount of acid solution which it is necessary to add to the flask, as measured by the graduation, to make the contents of the flask turn colorless is a measure of the alkalinity of the condensate and consequently of the excess Coravol present in it. This procedure is, in effect, simply the titration of 50 c.c. of condensate with standard acid solution, to a phenolphthalein end point, without the inconvenience of having to use a burette.

In starting the use of this treatment, substantial dosages are fed direct to the boiler, with samples of condensate tested from 1 to 2 hr. after each feeding, according to the rate of circulation in the system. After the concentration of Coravol in the system has been built up, and the alkalinity of the condensate established within the limits recommended, only enough need be added from time to time, usually once each day, to maintain the concentration within those limits.

Practical results observed in the use of Coravol check completely with the effect predicted from the theory of its action. A typical example of the application is its use in the heating plant of a large public building.

Boilers operate at 115 lb. pressure 24 hr. a day with a daily evaporation of 106,000 lb. The makeup, with a CO_2 content of 35 p.p.m. runs 3 per cent. Approximately 1000 ft. of 3 to 6 in. pipe is involved. In this plant there was excessive corrosion of steam lines and nipples and channeling of return lines. Replacement of pipes and fittings was frequent and expensive. Examination of the steam and condensate indicated an acid condition with a pH as low as 6.2. Oxygen in the condensate was 4 p.p.m.

In starting the use of Coravol, it was introduced into the suction line between the heater and the pump. The temperature of the condensate at the point of sampling was 150 deg. F. The amount used to establish initial alkalinity throughout the system was 4½ gal. This dosage created a pH of 9.4 in the condensate.

The pH regularly maintained by the operator, however, is 8.6 to 8.8, which requires a dosage of 1 quart per day. This alkalinity corresponds to a reading of approximately ½ c.c. in the testing flask. The corrosive action previously observed has been completely arrested by this procedure.

BOULDER DAM, which was completed over a year ahead of original estimates and now has ¼ of the planned generating machinery installed, is generating between 130,000,000 and 150,000,000 kw-hr. a month, which is sold to cities in southern California and to power companies in California and Nevada. During 1937, revenue from the sale of power was over $1,110,000. Present equipment is four 82,500 kv-a. generating units and one of 40,000 kv-a., the cost of dam, present equipment and interest during the construction period being $123,000,000.

Readers' Conference

Boiler Patches

REGARDING the communication in the March number of Power Plant Engineering by John J. Timmons, according to my conception, the A.S.M.E. Code is the "Daddy of them all" when it comes to being an authority on boiler construction. If you will compare the code of such states as Massachusetts, Ohio, Pennsylvania, New York, and Wisconsin, you will find that the state laws follow the A.S.M.E. Code word for word and section for section,. The A.S.M.E. Code is changed from time to time as the Boiler Code Committee sees fit and the various states amend their codes to keep in line. Several other states that do not have so complete a law at least state that a boiler built and stamped with A.S.M.E. symbol or with stamp of National Board of Boiler and Pressure Vessel Inspectors will be acceptable in that state.

It is the avowed aim of the Board of Boiler and Pressure Vessels Inspectors to secure uniform laws in all states to conform as nearly as possible to the A.S.M.E. Code. The latter code is thus much more than "suggestive" as it forms the basis for most of the state laws.

Note that the statement of the last paragraph of Mr. Timmons is entirely misleading as for many years it has been the custom in code states to penalize by cutting the pressure on boiler patches that were improperly designed even if the patches were under 24 in. longitudinally. The only exception I know of is where there is a round patch not more than 8 in. in diameter or a single riveted longitudinal seam not more than four rivets long.

After putting a patch on a boiler it has been the custom to re-rate the working pressure of the boiler to conform to the efficiency of the patch seam,—that is if the efficiency of patch seam fell below the efficiency of longitudinal joint.

Logansport, Ind. C. C. CUSTER.

Humanizing the Engineer

LOOKING BACK over our college days we well recall the calculus courses, heat engine laboratories, engineering reports, football seasons, fraternity initiations, and other more or less related activities. We spent four glorious years there (if we were fortunate enough) and absorbed knowledge of many sorts—technical and otherwise. Power factor we learned, for example, was the cosine of the angle θ; boiler efficiency turned out to possess several meanings. And Alma Mater (we discovered) is a phrase which brought fond memories to mind whenever we sang about it.

Later, settling down to our engineering work, we found that in the maze of information we had acquired, a good deal of the highly specialized, technical knowledge was, of necessity, left unused. Through the force of daily circumstances we grappled with the more immediate and practical problems of operation and maintenance which we found confronting us.

As we progressed in our profession we discovered, moreover, a rather startling fact. The presidents, vice presidents, general managers—in short, top management—men who were guiding the destinies of our companies—were masters in one very vital phase of human endeavor. They knew, we discovered, how to handle MEN as well as MACHINES. This most important, most vital development in the make-up of any successful executive—the ability to know and understand MEN—we had overlooked almost as completely as though it never existed.

This limitation of the engineer is, however, today being frankly recognized and vigorously corrected. At Massachusetts Institute of Technology, for example, students receive practical and fundamental training in human relations. A Chair of Humanics has been established there. In addition, English, both oral and written, has been made a major requirement throughout the engineering course. Concerning the human relations work in which these students are engaged, Dr. Karl Crompton, President, has made the following analysis:

"Under the leadership of Professor E. H. Schell, this program involves supplementing the customary type of graduate work—with a skillfully arranged and frequent series of meetings at each of which a half-dozen or so of these students and a professor or two dine with a top executive of some business organization, and then proceed to an informal discussion. Generally these discussions are still proceeding vigorously as midnight approaches. The executives get quite a kick out of the experience and in the course of a year the young men come really to have some little appreciation of the problems, policies, methods of thought and operation, of a variety of types of successful executives". (From "Education and Business Leadership".) ,

Stevens Institute of Technology is another shining light in the humanizing program. Here a staff of professors headed up by the Department of Humanities, assumes the difficult task of broadening the horizons of young engineers. In the course of their work the students supplement their technical studies with history, fine arts, psychology, musical appreciation, and English, both oral and written, throughout the four years. Here, too, has been established a Vocational Guidance Laboratory of far reaching influence. As a result of this important department students admitted to Stevens as freshmen are definitely known to possess inherent characteristics which will contribute to their future success in the engineering profession. Applicants found not qualified for technical work are eliminated before matriculation.

Yale, Cornell, Dartmouth, Purdue and Stanford are other leading institutions where "humanities" are not only offered, but are required in greater or lesser extent throughout the engineering course. Heads of technical schools and colleges are realizing today, as never before, the importance of developing, to the fullest possible extent, the personalities and inherently human traits of these technically minded young men.

There is yet another field in which the engineer, to his own great benefit, can broaden himself immeasurably. This activity, moreover, is open to the young and the old, to the rich and the poor alike. It is in the field of hobbies! Dr. Michael Pupin, for example, past president of the American Institute of Electrical Engineers, designer of the famous "Pupin Loading Coil," and recipient of the coveted Edison Medal, became widely known throughout the world as a great inventor.

What is not so well known, however, is the story of his hobbies. This, it is safe to say, is equally as fascinating as the record of his scientific achievement. How he trained two beautiful hackney horses out on his farm in Norfolk, Connecticut, and eventually won first honors at the National Horse Show in Madison Square Garden, is written in the annals of the American Horse Show Association. His "loading coil" for long distance telephone transmission brought him fame and fortune. His two beautifully balanced horses, however, made the "joy of life surge through his veins," as quoted from his autobiography. There is a grave question as to which Dr. Pupin held more dear—his hobby or his invention. And because of his hobbies, one of America's most eminent scientists became a very lovable and human individual. Professor Pupin's influence on young engineers at Columbia University has been far-reaching, and his ultimate enjoyment of life most complete.

Dr. Vladmir Karapetoff, at Cornell University, famed authority on electrical and magnetic circuits, once gave an involved lecture at a National Convention of the American Institute of Electrical Engineers, on the higher mathematics of the Fourth Dimension. Present were the country's leading engineers, intently listening. After completing his lecture the Professor folded his intricate plans with which he had been demonstrating, smiled, and said modestly "I'm afraid you could not enjoy my lecture. No one knows very much about this subject, anyway. So perhaps I can repay you for your courteous attention in some other way." Then he seated himself at a nearby piano and gave himself up to his love of music. His recital which followed was unusually enjoyable. As his fingers tripped lightly over the keys, the Professor's countenance became transformed. The preludes and nocturnes came floating to his audience, and his listeners were captivated by the beauty of his playing. What enjoyment Dr. Karapetoff derives, and gives to others, in his interpretation of the great composers of music!

Among the hobbies of other famous scientists, we find the late Alan Hazen, hydraulic consultant, making excellent silhouettes of his frequent house guests! The great Einstein revelled in the pleasure of his violin. A well known Chief Engineer of a large utility company is a master in the fine art of making etchings. A director of a famous research laboratory, strangely enough, has made a life hobby of collecting and studying the habits of turtles! Dr. David Starr Jordan, famous biologist and educator, was, among other things, a great student of democratic government and was widely known as a "minor prophet of democracy". Is it not possible that every scientist, engineer, technician, and research man can feel the thrill and the complete enjoyment of a chosen hobby? And in so doing, it is not too much to say that he will broaden his own personality, his own interests, his own viewpoint, far beyond the confines of his present scientific environment—to his own great and everlasting benefit.

Other phases of this humanizing scheme are the opportunities for self-development through civic responsibility. The presidency of a local service club may involve a substantial amount of time and effort, but the engineer who will assume this work will find the fruits of his endeavor quite as valuable a contribution to his success as a corresponding period spent in the great halls of learning. One of the members of the staff of a large technical society is first selectman in his home town—work which is not without its compensation in dealing with his fellow men. Examples the country over indicate conclusively that engineers, when they enter into community and civic work, develop untold and unexpected capabilities through contact with men in every walk of life.

An age-old axiom which all engineers might well heed and follow, to their ultimate and everlasting advantage in their personal achievement, as well as in their professional advancement, might not be out of place in these pages of Power Plant Engineering:

> A knowledge of MEN—as well as THINGS is above all the key to power.

In developing the human side of his make-up as well as his proficiency in handling machines, the engineer will discover not only that his job will become a mere stepping stone to much greater achievement but also that the world will become a far more fascinating place in which to live.

Waterbury, Conn. L. M. Duryee.

Noise in the Power Plant

Noise has been known to drive otherwise good men to the bug house; there is little that anybody can say in favor of noise except that it has provided jobs for so-called noise engineers. Every power plant man can, and should be more or less of a noise engineer.

Perhaps you agree with this but are conscious of the cost—that it is expensive to eliminate vibration by resetting machines. You say you cannot afford it. You are right, but have you checked up on other noises which can be eliminated inexpensively, chiefly by the use of a little gray matter? If you haven't done so, start right now. Here is the story of how such a noise was conquered.

Did you ever hear an automobile equipped with vacuum cup tires? Remember the constant roar? Then imagine a tire six feet in diameter with approximately forty, two-inch cups around its circumference, revolving 175 r.p.m. In other words 70,000, shall we say "gulps" a minute—not an audible frequency but producing a roar so loud that it is impossible to carry on a conversation in a normal tone of voice. After five years the writer was so fed up with the noise that he actually did something about it and now it is practically dead.

The offender was a combination flywheel and drive pulley on a unaflow steam engine furnishing power through a 12-in. belt to a 30-t. ammonia compressor. Just why the engine manufacturer placed the holes for pinching the engine off dead center in the face of the wheel is an unsolved mystery. As it is, the belt covers the holes ($1\frac{7}{8} \times 1\frac{7}{8} \times 1\frac{7}{8}$ in.) for approximately half of the cir-

cumference, and when parting from the face of the wheel tends to create a vacuum in the holes resulting in an inrush of air with attendant noise.

The elimination of this noise was slow in coming, possibly because there were two problems. First, selection of a suitable material with which to fill the holes; and second, how to pinch the engine off dead center after the holes were filled. Incidently, the second problem was solved first by moving the pinching bar so that it would act on the slots in the edge of the flywheel of the ammonia compressor.

The first problem was not so easy, as the material would have to cling tightly to the smooth iron walls of the holes so as not to be thrown out by centrifugal force. Also, to be absolutely safe, it had to be of such material that if it should come loose it would not be dangerous to employees or to the belt or the machines themselves when thrown from the wheel. The material which proved acceptable was cork, in the form of compressed corkboard used for cold storage insulation. Cubes, measuring two inches, were cut from two inch thick corkboard, forced into the 1⅞ inch holes, and then smoothed off flush with the face of the wheel. No trouble has arisen from flying cork, as it is too light to be forced out of the holes in half a revolution. As for noise, it is now possible to hear the compressor valves operate when standing next to the engine.

Williamson, N. Y. HARVEY A. PRATT

Correction Note—Montville Sets a New Record

MONTVILLE STATION of the Connecticut Light & Power Co. was described briefly in an article on page 85 of the January, 1938, issue. Figure 1 was intended to be a cross-section of the Montville turbine but through an error, the illustration used was that of the West End turbine, a 35,000 kw., 1200 lb., 900 deg. F. topping turbine for 260 lb. ga. back pressure operation. The

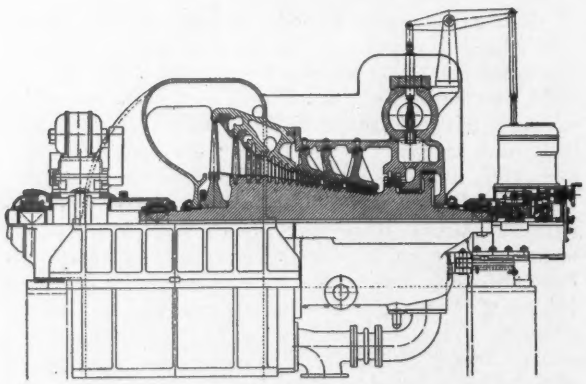


Fig. 1. Cross-section of the Montville turbine. The steam chest is built integral with the cylinder cover. Note the opening at the end of the last two rows of stationary blades provided for draining moisture from the steam direct to the condenser

cross-section of the Montville turbine is shown by the accompanying illustration. This is a 25,000 kw. unit, the largest 3600 r.p.m. condensing machine yet built. It operates at a throttle conditions of 640 lb. ga., 825 deg. F.

Wanted: A Reliable Boiler Draft Drop Formula

DURING the past 10 yr. this writer has been endeavoring to secure some authentic information on draft drop through water tube steam boilers, but without satisfactory success. So far as I have been able to learn, nobody has yet been successful in producing a formula or chart for determining draft drop which is really reliable. There are formulas and charts in several books, to be sure, but they are of little practical value. The difficulty is, there are so many variable factors that must be taken into consideration, such as temperature of the gas, velocity, parallel flow in parts of the boiler and cross flow in other parts, slag, ash and soot formations, variable sections and occasional open spaces from one end to the other, turns, eddy currents, and a small pressure to begin with. In addition, most of these factors are seldom alike in any two boilers. Every boiler is "different," even from its twin sisters, after it is once placed in operation. Boilers seemingly identical, side-by-side, operating on the same coal, with the same water, same fireman, same everything, will give different evaporation test results and will show different drafts.

All of which makes it rather difficult for boiler merchants to guarantee that the draft drop will be "so and so." It is not at all uncommon for purchasers of boilers to require a draft drop guarantee. In fact the draft drop guarantee often is made a part of boiler modernization contracts. The contractor, even though he is entirely at sea as regards draft drop computations, nevertheless "takes a chance" and signs, hoping that the draft will be all right.

Below are typical paragraphs from letters on the subject that I have received from "experts." The writer of the following has a national reputation:

"We do not know of any dependable formula or chart for determining draft drop through any steam boilers. It would appear to depend so much upon the design of the particular boiler that the preparation of a general formula or chart would be difficult, and perhaps impossible."

The following, by a boiler manufacturer, hits the nail squarely on the head. They state that they use empirical formulas in which components must be used with "considerable judgment." In this instance there is a close relationship between "guessing" and "judgment," the principal difference being that the word "judgment" is likely to have greater weight with boiler users and engineers. Most of us, when we guess, usually apply our best judgment during the guessing process. Here is a portion of the letter:

"The question of figuring draft loss through boilers nowadays with the multitude of fuels, variety of designs and baffling is a very involved one. We have evolved certain empirical formulas the components in which have to be used with considerable judgment. You can see, therefore, that such formulas are really our 'stock-in-trade' and we have never allowed them to go out for general use. A good many customers today give draft loss a certain weight in the purchasing of boilers; for instance, your boiler price may be high but when given credit for draft loss it might work out cheaper than

the competitor's offering with a lower price and a higher draft loss. You can see from this that some of our competitors would be very glad to find out just how our company does figure draft loss and naturally if we start giving out our data to one we cannot very well refuse it to all. We never know in whose hands these data may come to our detriment."

Here is a letter from the spokesman of a national body of engineers who neatly side-steps by referring to a book:

"The best source of information for determining the draft drop through steam boilers seems to be that contained in the ———— ———— handbook. There is considerable discussion of this question which gives various factors that affect the draft."

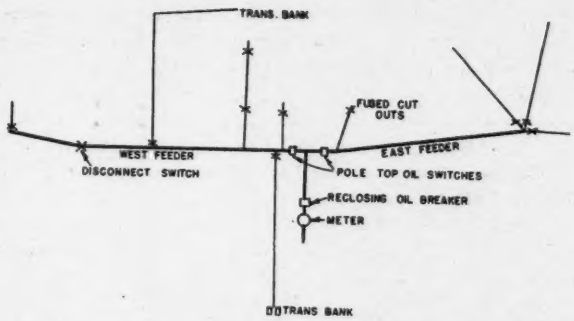
This writer hopes that the above letters and discussion will lead to something more definite and reliable than now exists on the important subject of draft drop. Without draft, boilers cannot function. With partial draft they can function only partially.

Newark, N. J. W. F. SCHAPHORST.

Sectionalizing Switches on 2400 Volt System

THE USE OF 2400 v. 3-phase current for distribution around an industrial plant is becoming more common every day. This is especially true of industries which occupy a group of buildings spread over considerable area. The problem of maintenance on such a system is different from that encountered in public service lines. In the case of the industry it is possible to cut out certain sections at times when it is necessary to work on the lines. Also in case of trouble, a fire, or a damaged line it is necessary to cut the current from the line without disturbing more of the factory than necessary. Large group drive motors for different sections can be given better voltage and for lower voltages a transformer can be hooked on the line. Besides this there is usually a 5 per cent discount on the electric bill where the metering is done on the high side.

The accompanying sketch gives the general distribution system of a large industrial works with the various oil switches and disconnect switches on the 2400 v. side. The main breaker in the center feed is of the reclosing type set to handle the full load of both main branches. The metering is also done at this point. In case of a short or surge the breaker will operate and if the short persists the breaker will close and then reopen. It will reclose three times, after which it locks in the open position. In cases of lightening or a swinging short the breaker will reclose and hold in as long as the line is clear. In order to facilitate repairs or to cut off either end of the line in case of emergencies, a pole top oil switch is located on each of the main branches as indicated. As there are quite a few branches to the main feeders going both ways it would be impossible to determine whether everything was out of use. It would be dangerous to open an ordinary air break disconnect under load, but with the oil switches it is practical to do this. At or near the main feeder where the branch circuits leave it are placed fused disconnect switches which may be pulled out so that work can be done on that particular branch. It is possible to check on any one department to see that they are not opened under



General distribution system of a large industrial plant

load. These fused cut outs are indicated by crosses. They are installed either on poles or on the side of the individual motor houses as occasion demands. In case of a ground on one of the lines the switches can be used to locate it by cutting off one circuit at a time. Such an arrangement gives the maximum amount of protection to the line and also promotes safety.

Sayreville, N. J. K. B. HUMPHREY.

Removing Ash from Dry Bottom Furnaces

EVERY PRECAUTION should be observed when removing refuse from dry bottom pulverized fuel fired furnaces to prevent the occurrence of minor explosions or puffs which may endanger personnel, furnaces and continuity of operation. Care is especially needed during light load periods when flame conditions are unstable and the refuse contains a high percentage of unburned carbon. If agitated so that it becomes suspended in the air entering through the ash disposal opening this material is highly combustible and may ignite with explosive violence.

After experiencing a number of puffs directly attributable to faulty ash removal procedure the management of a large industrial power plant has set up a standard procedure for this operation. Since placing this code in force, puffs have been practically eliminated. It reads as follows:

STANDARD PRACTICE FOR REMOVING REFUSE FROM DRY BOTTOM FURNACES EQUIPPED WITH HYDRAULIC ASH SLUICING SYSTEM

OPERATOR SAFETY

The operator performing this operation shall wear a cap, gloves, goggles and have his sleeves rolled down so that a minimum of bare flesh is exposed. He shall keep the observation parts of the disposal hopper closed except when conditions permit visual observation.

PROCEDURE

1. Notify the fireman of readiness to dump ashes.
2. The fireman will:
   (a) Increase furnace draft to 0.25 in. of water.
   (b) Speed up induced draft fan until a damper differential of 2.0 in. of water is shown by the draft gage.
   (c) Decrease flame turbulance until maximum flame stability for the load being carried is secured.

(d) Notify the ash disposal operator to proceed. While the operation is in progress the fireman will observe furnace conditions closely and if any irregularity occurs, order the ash hopper gate closed so that conditions can be immediately stabilized.

3. After receiving orders to proceed, the ash disposal operator will:

(a) Turn on the disposal hopper light.

(b) Open the slide gate slowly three or four inches.

(c) Observe if refuse is flowing. If no flow occurs, he will close the gate with considerable force to jar the accumulated material. If after doing this several times and no material falls, he will open the gate four inches and start the flow with a bar inserted through an observation port.

(d) When flow is started he will slowly open the gate to the limit of its travel. When wide open he will observe the ash pit. If much ash remains hanging up on the sides, it should be carefully dislodged with a bar, taking care that it is agitated as little as possible.

(e) When the ash pit is clean he will close the slide gate.

4. Notify the fireman that the operation is completed. The fireman will then restore furnace conditions to normal.

5. The ash disposal operator when sluicing hot refuse from the ash hopper should use extreme care when opening the sluice nozzle valve. Too much water suddenly applied is liable to cause the generation of large volumes of steam and water gas, which may cause an explosion.

Roanoke, Va. S. H. COLEMAN.

Fuel Oil Combustion

THE ARTICLE by E. G. Roberts in your February issue, entitled "Fundamentals of Fuel Oil Combustion," furnishes a very valuable contribution to the subject, and should be of interest to all those engaged in burning oil.

I was particularly interested in the reference to preheated air, and the more so after reading the article by J. R. Darnell, in the same issue.

There has been a great deal of difference of opinion expressed as to the economies which may be expected from the use of preheated air with oil burners, aside from the savings which can be made through the reclamation of waste heat, but I have long been of the opinion that although theoretically, the advantage may not be very great, under certain conditions which may sometimes be found in practice, it may be considerable.

Mr. Roberts has called attention to the fact that preheated air speeds up combustion, and perhaps, more important still, it advances the time of ignition.

Of course, one of the most important problems in connection with oil burning, is to get complete combustion before the gases strike a water cooled boiler surface, and it is also advisable that they should not impinge upon the brickwork.

A consideration of the design of many combustion chambers will make it clear that if we are going to avoid this, we shall have to be pretty quick about it, and we shall need every aid to rapid ignition that may be available.

For this reason, if for no other, I believe that preheated air is often of considerable advantage when burning oil.

For very much the same reason, I consider steam preferable to compressed air for atomizing. Compressed air cools while expanding, and if there is any place where we do not want a refrigerating effect, it is at the tip of an oil burner. A very slight delay in the time of ignition, will enable the unignited fuel to travel some distance, which may be a serious matter in the limited space available. Of course expanding steam is theoretically a refrigerant, but its high temperature largely offsets this.

Mr. Roberts states that the heat release should be about 30,000 B.t.u. per hour per cubic foot of furnace volume at nominal rating, and may go as high as 80,000 at high ratings. I have no criticism to make of this from a theoretical standpoint, but it may be well to keep in mind the fact that in some localities there are strict smoke ordinances, and they seem to be spreading. In the vicinity of New York the tendency appears to be, to limit us to 25,000 B.t.u. release, and in practical operation, to require 1½ cu. ft. per boiler horsepower. Before you can get a permit, you have to state how many horsepower you expect to develop, and personally I have not found the authorities at all enthusiastic about allowing high heat releases when forcing the boilers.

The growing tendency on the part of public authorities to establish rules for the abolition of smoke, is something which I think, should meet with general approval, so in practice, it might be good policy to follow the requirements of the more conservative established regulations when designing boiler furnaces, even if such regulations are not at present in force, in the district in which we are operating.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Air Compressor Operating Costs

HAVING HAD occasion to make practically the identical comparison, my attention was attracted by C. C. Herman's article on air compressor operating cost, on page 202 of the March issue of POWER PLANT ENGINEERING.

I found it difficult to reconcile the great difference in cost of compressed air, using steam as the motive power, as against electric power, until I noticed an error in addition under the electrical calculation, making the cost per thousand feet of air $0.1329 instead of $0.0928. This does not change Mr. Herman's conclusion that the installation of the electric motor for summer operation would not be justified.

A further point that seems too favorable to the electric power drive is the assumption that the steam plant could be entirely closed during the summer months; it seems unreasonable that a plant of a size requiring from 500 to 1000 cu. ft. of air per minute would not require some steam for its operation, even for the summer months.

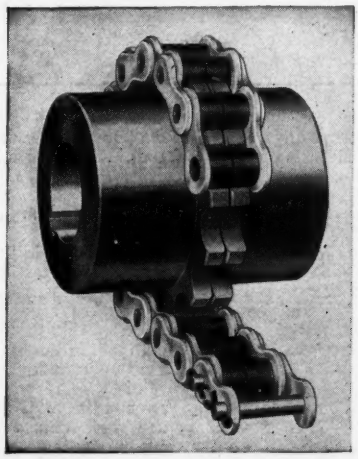
Stowe, Pa. C. S. STOUFFER.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Flexible Coupling

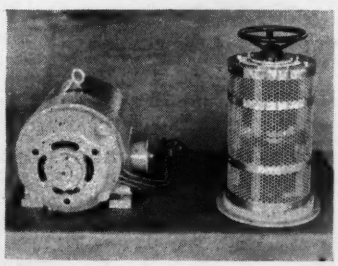
LINK-BELT Co., 307 N. Michigan Ave., Chicago, Ill., announces the development of a new flexible coupling, which embodies major improvements over the company's Type "RC" roller-chain coupling. The new coupling consists of two cut tooth sprocket wheels (or coupling halves) which are connected by a piece of specially constructed single-width finished



steel roller chain, using a recently-patented divided-roller feature which combines the advantage of double roller chain with the more rugged and simple construction of single width chain.

Polyspeed Motors

THE CROCKER-WHEELER ELECTRIC MFG. Co. has developed a new Polyspeed Motor, which it appears offers an excellent solution to the problem of alternating current motor speed control, at least in smaller sizes. This motor is operated in conjunction with two induction voltage regulators. The motor has a laminated stator core with a winding similar to that of a 3-phase induction motor. This stator winding is connected directly to the 3-phase power line and requires no adjustment. The laminated rotor core has a single winding similar to a normal direct-current armature winding and is connected to a commutator in the usual manner. Three brush



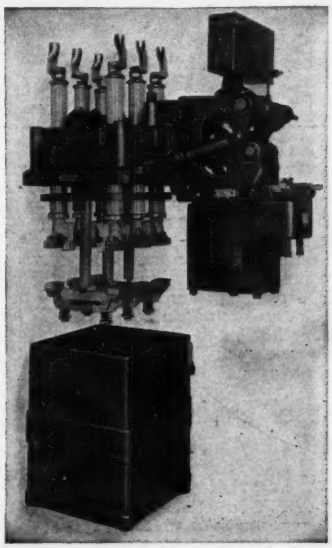
studs per pair of poles are provided, these being set in a fixed position.

The speed regulator consists of two, single phase induction type, voltage regulators, placed in one frame, with the two rotors mounted on a common shaft. The primary windings are located on the rotors and connected through flexible leads to the same 3-phase source of power as the stator winding of the motor. The two secondary windings are placed on the stationary elements and connected to form a source of 3-phase voltage which is applied to the motor brushes to provide the adjustable voltage for the regulation of the speed.

At the present time these motors are to be built in sizes ranging from 1 to 7½ hp. Crocker-Wheeler Electric Mfg. Co., Ampere, N. J.

Indoor Oil Circuit Breaker

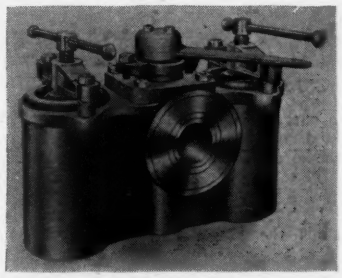
A NEW INDOOR OIL circuit breaker, called the type DX-40, is being manufactured at the Condit Works of the Allis-Chalmers Mfg. Co. at Boston, Mass. It is designed for heavy duty starting of large synchronous and induction motors. It is especially recommended for steel mill service, including rolling mill starting and jogging. It will operate many



thousands of times under load without requiring attention it is claimed. A special feature is the use of "expulsion ports" which hasten arc extinction. Among the other features are: large, butt-type arcing contacts; main contacts of wedge and finger type with silver contact surfaces; cast steel top frame; reinforced, electrically welded steel tank; one-piece Bakelain bushings; low inertia, straight-line-motion type mechanism; mechanically trip free manual or electrical operator. The breaker is furnished for 600 and 1,200 amp. at 15 kv. with an interrupting capacity rating of 100,000 kva.

Duoflo Suction Oil Strainer

APPLICABLE to industrial oil burning furnaces and oil processing lines, the Duoflo Suction Oil Strainer is made of semi-steel and has two perforated baskets held in place by the covers. This duplex construction allows one strainer to be cleaned while the other is in operation. Cleaning of one of the strainers is easily accomplished without interfering with the



operation of the system. It is only necessary to turn the plug cock, deflecting the oil through the other strainer, and remove the basket to be cleaned. The strainer baskets are large and have a straining area much greater than that of the oil intake pipe.

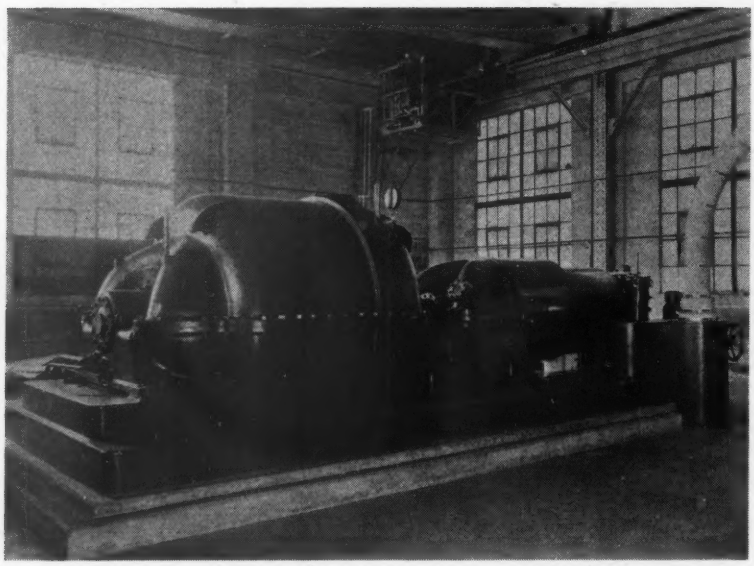
Duoflo strainers are made in five sizes, from 1½ to 4 in. to suit the requirements of the system installed. All suction strainers are flanged and drilled to American Standard Specifications. Each assembly is hydrostatically tested to 150 lb. per square inch before shipment. Sheffler-Gross Co., Inc., S. E. Corner 5th and Chestnut St., Philadelphia, Pa.

Portable Bar-to-Bar Test Set

TO PERMIT electrical resistance tests on d-c armatures to be made anywhere, the General Electric meter and instrument division has developed a portable bar-to-bar test set. Previously it was necessary to take a d-c armature to the unwieldly testing equipment in order to compare the electrical resistance of coils measured between adjacent commutator bars. Now, using this instrument, which is complete and portable, an armature may be tested anywhere.

The test set is a resistance comparator, and hence is useful wherever a comparison of resistance is required. Consisting essentially of a step-down transformer, a rectifier, and a sensitive "light-beam" galvanometer, it is designed to give a full-scale deflection in the resistance range of 0.0001 to 35 ohms.

The bar-to-bar set is shipped complete and ready for use. To put in operation, a plug furnished with the set is connected to any convenient 115 volt, 60 cycle outlet. Leads from the four binding posts are attached to the commutator, two furnishing

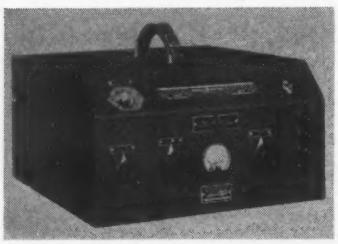


Wind for Another Furnace

ALLIS-CHALMERS MFG. Co. designed and built this turbo blower recently installed by the Freyn Engineering Co. to serve a 500-t. blast furnace at the Hamilton Coke & Iron Div. of the American Rolling Mill Co. The air end consists of a 4-stage uncooled Brown-Boveri type centrifugal blower, with a capacity of 40,000 c.f.m. at 30 lb. ga. and a speed of 3630 r.p.m. The steam end consists of a standard condensing reaction turbine rated at 4600 hp. at 3630 r.p.m. and an Askania constant air weight regulator. This regulator automatically varies the speed of the unit so as to maintain a constant standard volume of air delivered to the furnace, regardless of changes in atmospheric pressure and temperature. The blower is fitted with hand-operated movable diffusers, a feature which makes it possible to reduce the capacity of the blower to very low limits without pumping or surging.

the current supply to the resistance being tested, and two being the terminals of the drop circuit, leading to the galvanometer.

The "low resistance" position of the dial knob on the panel is used for values of 1 ohm or less; for greater resistance values the "high resistance" position is



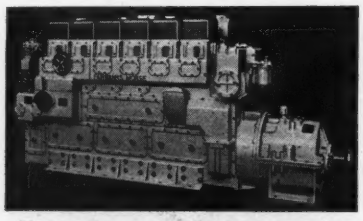
used. In order to compare resistance between different bars, two particular ones are chosen and the instrument set for 100 per cent deflection by adjusting the "current," "range," and "sensitivity" rheostats until the desired deflection of the light-beam galvanometer is obtained. By contacting successive commutator bars with the lead extremities, the resistance of the coils connected to them will be indicated directly in per cent of the original setting.

Convertible Gas and Diesel Engine

TO FILL A DEFINITE need for sturdy, medium-speed engines in the 200 to 300 hp. range, Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Ill., has announced a series of four-cycle, vertical, convertible Diesel and gas engines known as Model 36-A-8. Built in both six and eight-cylinder combinations, with 8-in. bore and 10½-in. stroke, they develop 35 hp. per cylinder at 720 r.p.m. Smaller sizes are available in rating as low as 8 hp.

Both Diesel and gas engines in the new 8-in. cylinder size are offered for stationary service, and the Diesels are offered for marine propulsion and in complete, unit-built Fairbanks-Morse generating sets as well. The Diesels for marine service are direct-reversible, but can be furnished as non-reversible where such service requires.

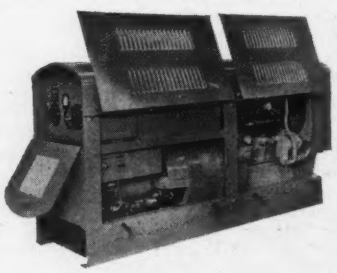
Guided by the objectives of reliability, and economy in service, the resulting engine is extremely simple, neat in appearance, completely self-contained, sturdy and dependable, with excellent fuel and lubricating oil economy.



Enbloc construction is employed, with individual cylinder-liners, precision main, connecting-rod and cam-shaft bearings, and suspended or "underslung" crankshaft. Side cover-plates permit easy accessibility to main and connecting-rod bearings. The design permits double-end drive or power take-off from either end, a distinct advantage in certain types of application.

Diesel Engine Driven Arc Welder

A NEW Diesel engine, which differs radically from the popular conception of this type of power has been adopted for driving arc welding generators by engineers of The Lincoln Electric Co., Cleveland, O., in collaboration with Diesel engine manufacturers. Development of this new Hercules engine brings the economy of Diesel operation to all applications of welding requiring engine driven arc welding generators.



The new Diesel driven welder is the result of extensive research and testing to develop a power plant of correct design and construction to meet requirements of welding service. Built to the specifications of Lincoln engineers, the Diesel engine has been operated in the field in severe service and has performed satisfactorily under all conditions.

This new Lincoln welder cuts fuel costs 33 to 86 per cent, depending upon the price of fuel oil used. For instance, at full load operation, it uses only 1.5 gal. of fuel oil per hour as compared to 2¾ gal. of gasoline per hour required for the conventional gasoline engine driven welder.

The arc welding generator used on the new Diesel engine driven welding machine is the 300-amp. Shield-Arc SAE unit equipped with dual-continuous control.

Target Operation of Relays

TO PROVIDE more accurate operation and indication, improvements in the target operation of its Type RDC and HEA relays have been made by the General Electric Co., Schenectady, N. Y.

Type RDC high-speed current-balance relays for protection of parallel lines against phase-to-phase faults have been improved by the addition of electric targets to replace the mechanical targets used previously. Electrically operated targets have the advantage of avoiding indication unless the relay actually accomplishes its function by the closing of its contacts and passing the tripping current through its target coils. Mechanically operated targets may drop to indicate relay functioning even when the relay did not operate, because of an open-circuited trip circuit that was opened by some other device.

The Type HEA multicontact auxiliary relay operates so rapidly that when its coil, connected in series with the protec-

tive relay contacts and target coil, is disconnected by means of one of its own contacts, the time is so short that in some cases the target of the protective relay does not drop to indicate that the relay has functioned. This condition is not caused by inadequate operating current but by the armature of the target coil operating and falling back before the target latch is released.

Oxy-Acetylene Hose

A NEW oxy-acetylene hose, known as Duoweld, has been announced by The B. F. Goodrich Co., Akron, O. It consists of two strands of ¼ in., 2-braid hose with corrugated cover which are molded together as a single unit. To aid the operator in identifying the acetylene from the oxygen line, the cover on one strand is red, while the other is green. Advantages claimed for this dual construction are that it prevents the two lengths of hose from becoming tangled with each other; eliminates kinking and is less apt to snag on surrounding objects. Goodrich Duoweld hose is offered in 12½ ft., 25 ft. and 50 ft. lengths. Each length is separated and secured with metal ferrules about a foot and a half from the ends for easy attachment to equipment.

Draft Control

THE SEQUENCE Furnace Draft Control was developed by The Hays Corp., Michigan City, Ind., to prevent the annoying "blow-back" that occurs at the ignition period in the "on and off" type of oil and gas burners and stokers. The control is

electrically operated and is timed so as to open the up-take damper wide an instant before the burner or stoker comes on. In this way no pressure is built up in the Combustion Chamber and the ignition is accomplished without the usual "explosion". Immediately following the establishing of proper combustion the damper is closed to the position required to maintain good combustion and from that point on the regular draft control maintains the proper draft.

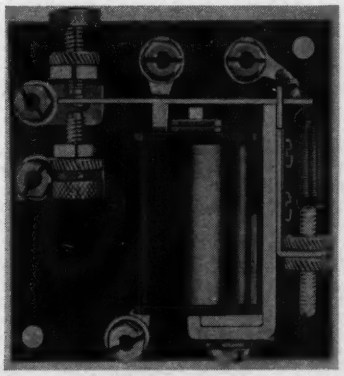
Improved Carbon Steel Wrenches

AN IMPROVED TYPE of carbon steel wrench is being supplied by J. H. Williams & Co., 76 Spring St., New York City, in a complete standard line consisting of 50 patterns and more than 1000 sizes. These wrenches are reported to be approximately twice as strong as old-fashioned carbon steel wrenches and average 93 per cent as strong as alloy steel wrenches of similar size.

The unusual strength characteristics of these wrenches are said to result from the fact that they are drop-forged from improved quality carbon steel and specially processed to the exacting specifications of the manufacturer.

A. C. Sensitive Relay

WARD LEONARD ELECTRIC CO., Mount Vernon, N. Y., announces a new A. C. Sensitive Relay. The new relay is available with single pole, double throw contacts. A high degree of sensitivity, good contact torque at pull-up and a crisp constant drop-out is made possible by the use of nickel alloy in the magnetic circuit.

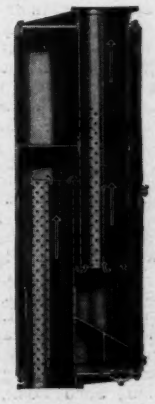


Coils are available for currents from 1.5 to 450 milliamperes. Large knurled nuts facilitate adjustments of silver contacts and armature spring tension.

The relay is furnished with a bakelite base approximately 2 in. square and may be mounted in any position without altering its performance.

Diesel Muffler

TO ELIMINATE fire hazard from industrial and marine Diesel engines, Burgess Acoustic has developed the ATP Series spark arresting exhaust muffler. This new unit removes carbon particles and sparks of all sizes from the exhaust gases before they are discharged to the atmosphere. It is of the modified three-pass construction. Exhaust gases enter from below, are diverted downward, then upward, and out. The low restriction of this muffler is made possible by the large open passages and by the cross flow of gases from one passage to the other through perforations. Reactance chambers at the inlet and outlet end



suppress the low pitched noises while the high pitched noises are dissipated in the spark arresting chamber. Bulletin 332 will be sent on request. Burgess Battery Co., Acoustic Division, Dept. NR, 111 W. Monroe St., Chicago, Ill.

Dew-Point Potentiometer

FOR USE in determination of moisture content of atmosphere in industrial metal-heat-treating furnaces, the General Electric Co. has developed a new portable dew-point potentiometer.

The instrument consists of a polished, metallic mirror located in a small chamber in such a manner that it can be seen through a sight glass, and means for cooling the mirror and reading its temperature. Gas to be tested is passed continuously through the chamber; and, as the temperature of the mirror is lowered by a jet of carbon dioxide or some other gas from a storage tank directed against the back of

the mirror, a spot of dew appears when the dew-point temperature of the gas is reached. Formation of dew at the center of the mirror is very definite and is easily observed. A light-gauge thermocouple and a balancing circuit, with direct-reading meter, allow accurate reading of the mirror temperature at the instant that the dew appears. This is the dew-point temperature of the gas being tested, and it enables conversion to the weight of water vapor per cubic foot of gas, or other convenient unit. Range of dew-point temperatures of the instrument is from 130 to minus 40 deg. F.

News from the Field

THE AMERICAN DISTRICT STEAM CO., North Tonawanda, N. Y., announces the appointment of M. J. Gibbons Supply Co., 601 E. Monument St. as district representatives for the Dayton, Ohio, territory and Pacific Factors, 703 Market St. as district representatives for the San Francisco territory.

C. M. BREWER, president of The California Oregon Power Co., died March 2 in Medford, Oregon. Born in Marshall, Mich., in 1881, Mr. Brewer graduated from the University of Michigan and then entered the employ of Commonwealth Power Co. at Jackson, Mich. In 1909, he became associated with the H. M. Byllesby & Co. and in the ensuing years held sales and executive positions in several of the operating units of that organization at Mankato, Minn., Sand Point, Ida., Richmond, Cal., Albany, Ore., and Medford, Ore.

On November 27, 1931, Mr. Brewer was elected president of both the Mountain States Power Co. and The California Oregon Power Co. but resigned his position with the former company last year.

AWARD of contracts covering a 15,000-hp. turbine, a governor and a 12,000-kv-a. generator which will make up the third unit of the Seminoe Dam power plant of the Kendrick Federal reclamation project in Wyoming has been announced by the Government. The contract for the manufacture of the turbine and the governor went to the Pelton Water Wheel Co. of San Francisco, Cal., on its bids of $64,854 and $11,015, respectively. The contract for the manufacture of the generator went to the Allis-Chalmers Mfg. Co. of Milwaukee, Wis., on its bid of $102,575. The equipment covered by this contract makes up a generating unit which is identical with two previously ordered by the Bureau of Reclamation for the Seminoe plant. The plant, when completed, will contain three 15,000-hp. units. The Seminoe power plant will be at the toe of the dam, now about 55 per cent completed in the North Platte River southwest of Casper, Wyo. The dam and power plant will be the principal engineering features of the Kendrick project, designed for the irrigation of 35,000 acres in the vicinity of Casper. Contractors will be expected to deliver the machinery within 300 calendar days.

EAGLE-PICHER SALES CO. has recently approved, as distributors for the Eagle-Picher line of industrial insulating materials, including plastic insulation, pipe insulation and waterproofing compounds, the following companies: Automatic Coal Burner Co., Beckley, W. Va.; Bemis Refractories Service Co., Springfield, Mass.; Corbett-Wallace Corp., Houston, Texas; Joseph A. Coy Co., Tulsa, Okla.; G. M. Hardware Co., Beaumont, Texas; H. R. Kelly Co., Inc., Brooklyn, N. Y.; Fred H. McGee, Chattanooga, Tenn.; McLean-Peterson Co., Cincinnati, Ohio; United Brick & Tile Co., Oklahoma City, Okla.; United Engineering & Equipment Co., Nashville, Tenn.

TO ROUND out its home-study courses in the field of heating and ventilating, Rutgers University, New Brunswick, N. J., is now offering a course in oil burner engineering in fifteen sections or lesson assignments. Already available were the newly-revised air conditioning course and one in heating and ventilating. The course, intended for service men, salesmen, mechanics, electricians and engineers, presents the fundamentals of oil burner engineering in a text especially adapted to individual study. Included in the outline of the course are the following study subjects: oil fuels, specifications, comparative costs, combustion, atomization of oil fuels, oil burner operation, automatic control devices, oil-fuel tests, calorific value of fuel oils, basic heat principles, calculation of heating systems, methods of heating, duct sizes, steam boiler sizes, fan size, grate area, duct proportioning, calculation of heating requirements, heat loss calculations, estimating savings from insulation, fans and blowers, fan speeds, air compressors, draft and chimney dimensions and tests, air conditioning, heat and humidification.

THE 1937 LAMME MEDAL of the American Institute of Electrical Engineers has been awarded to Dr. Robert E. Doherty, President, Carnegie Institute of Technology, Pittsburgh, Pa., "for his extension of the theory of alternating current machinery, his skill in introducing that theory into practice, and his encouragement of young men to aspire to excellence in this field". The medal and certificate will be presented to him at the annual Summer Convention of the Institute, which is to be held in Washington, D. C., June 20-24, 1938.

SMOKE PREVENTION ASSOCIATION will hold its national convention May 17-20 at Andrew Jackson Hotel, Nashville, Tenn. A display will be arranged of stokers, boilers, smoke indicating devices and fuels, also of devices and methods used in the abatement of smoke and air pollution. Details may be obtained from the Association, 139 No. Clark St., Chicago, Ill.

TAX of 1 cent a gallon on oil used for heating or generation of power other than in Diesel engines is proposed in the Boland bill, H. R. 3134, recently introduced in the House of Representatives. This would be a tax of some 15 per cent on domestic consumers, railroads, steamship lines and oil-burning steam plants, which is obviously excessive, as well as a discriminatory increase in the cost of one kind of fuel.

W. R. GRACE & CO. has announced the 1938 awards of six engineering scholarships in collaboration with General Electric Co. and Ingersoll-Rand Co. to university graduates in Peru and Chile. These scholarships give students the advantage of practical shop experience in the works of coöperating companies, the plan being originated by D. Stewart Iglehart, president of W. R. Grace & Co. and students being selected by a committee in each country consisting of the American Ambassador, the managing executive for that country of W. R. Grace & Co. and representative educational and government leaders.

A new mining scholarship will soon be awarded in Bolivia for a year of study with Ingersoll-Rand Co.

Scholarships are awarded to graduate students who speak English. They provide free transportation to and from the United States with an 8 to 18 mo. stay and allowance of $125 a month for living expenses.

EDWIN W. NICK, president of the Northern Equipment Co., Erie, Pa., has been named a member of the National Co-operation Committee which is engaged in formulating a program of greater coöperation between Industry, the President, and the Congress. The committee is studying such problems affecting American business as Industrial Loans, Undistributed Profits Tax, Capital Gains, Public Utilities and Railroads. The purpose is to coördinate the activities of organized industry with those of other groups seeking solutions to the same problems in an effort to achieve permanent business recovery. Mr. Nick has expressed a desire to receive any and all comments and suggestions men in this field may have which they think would be helpful in solving this problem.

Complete membership of the committee is as follows: W. L. Batt, president SKF Industries; James F. Bell, chairman, General Mills; R. H. Cabell, president, Armour & Co.; E. T. Cunningham, New York; Lammot du Pont, president, E. I. du Pont de Nemours & Co.; Albus C. Higgins, president, the Norton Co.; Tracy Higgins, president, Charles M. Higgins & Co.; Cornelius F. Kelly, president, Anaconda Copper Mining Co.; F. W. Lovejoy, president, Eastman Kodak Co.; W. F. Maish, president, Little Crow Milling Co.; Thomas H. McInnerney, president, National Dairy Products Corp.; E. W. Nick, president Northern Equipment Co.; Roy L. Patrick, treasurer, Eastern Magnesia Talc Co.; H. W. Prentis, Jr., president, Armstrong Cork Co.; W. S. S. Rodgers, president, the Texas Co.; Alfred P. Sloan, Jr., chairman, General Motors Corp.; John J. Watson, president, International Agricultural Corp.

APPOINTMENT of George T. Mahaney and James D. Platt as eastern and western retail sales managers, respectively, of the Diesel Engine Division, General Motors Sales Corp., was announced today by William J. Davidson, general sales manager.

The two, whose territories will be divided roughly by an imaginary line extending from Mobile, Ala., northward through Chicago and Milwaukee, will maintain their offices at the headquarters of the new Diesel division in Cleveland.

Mr. Mahaney attended Gettysburg college at Gettysburg, Pa., receiving his degree in 1922, while Mr. Platt was graduated from the Sheffield scientific school of Yale university in 1924.

KOPPERS-RHEOLAVEUR CO., Pittsburgh, Pa., a Koppers Co. affiliate, has just been awarded a contract by the Franklin County Coal Corp. to construct a mechanical coal cleaning plant adjacent to the tipple at the corporation's Royalton Mine No. 7, Royalton, Ill. It is to be ready for operation by Aug. 1, this year. The cleaning plant, operating in two shifts, will have a rated feed capacity of 270 tons per hour. A Koppers-Menzies Cone Separator will clean 3 by 5/16 in. coal on the first shift and 2 by 5/16 in. coal on the second shift. Two Koppers-Battelle launder units operating in parallel will clean 5/16 in. coal on both shifts. Two Carpenter Centrifugal Driers will dry the latter coal. Provision is made for screening the washed coal and again mixing as desired.

ON APRIL 1ST Chicago office of the Crosby Steam Gage & Valve Co. will take up new headquarters on the Marquette Bldg. There will be no change in the personnel. Mr. Breor will continue as Western District Sales Manager, assisted by Charles Dempsey and Douglas Kier.

THE MURRAY IRON WORKS CO., Burlington, Iowa, announces the appointment of L. R. Merritt & Co., 250 Park Ave., New York, N. Y., as district sales representative for the sale of its turbines, engines and turbine drive unit heaters.

CUTLER-HAMMER, INC., Milwaukee, announces removal of its Cincinnati office to the American Building, Central Parkway at Walnut, to give improved facilities and service to the company's customers in that territory. M. C. Steffen will continue as manager of the office.

CHARLES D. POEY, for 20 yr. with Consolidated Edison Systems of New York, of late as illuminating engineer, has joined the forces of Greist Mfg. Co., New Haven, Conn., as chief engineer of its illuminating division. Mr. Poey is a graduate of Sheffield School of Yale University, a member of Illuminating Engineering Society, of A. I. E. E. and of American Standards Assn. Mr. Poey was given a farewell dinner by his associates of the engineering staff of Consolidated Edison at the Grammercy Park South Hotel as a testimonial of their regard.

THE MARLEY COMPANY announces that effective March 15, 1938, they will occupy their new warehouse and office building recently completed in the Fairfax Industrial District of Kansas City, Kansas.

MANNING, MAXWELL & MOORE, INC., Bridgeport, Conn., announces the assignment of nine new general field salesmen to territories. New territories have been created and salesmen with headquarters as follows to serve them: Charlotte, N. C., Paul Hayden; Jacksonville, Fla., W. H. Kissam; New Orleans, La., R. F. Heath; Minneapolis, Minn., K. W. Johansson; Columbus, Ohio, W. S. Adams. In some territories the offices have been strengthened by the following salesmen: New York City, V. W. Farris; Philadelphia, H. H. Jones; Chicago, H. B. Stallings; Tulsa, C. W. Velie. Two new district sales managers are also announced as a part of this sales force expansion. R. W. Neel, who has represented Manning, Maxwell & Moore for a number of years, is now in charge of the newly created Southeastern district with headquarters in Atlanta. Malcolm Black has been made manager of the Southwestern district with headquarters in Tulsa.

HARRY TERRY, who was vice-president of Cramer-Krasselli Co., until January, 1937, has removed his offices from 360 No. Michigan Ave. to 8 So. Michigan Ave., Chicago, Ill., where he will continue as advertising and sales economist.

CLAYTON S. COGGESHALL has been made general assistant to R. B. Beale, manager of the turbine division, central station department of the General Electric Co., effective March 1, it has been announced. He was formerly manager of sales of the turbine division, Lynn River works. John L. Kerr, previously turbine specialist in the Central District, has taken Mr. Coggeshall's place at Lynn, and Robert S. Neblett has become manager of sales, Schenectady section, turbine division.

NATIONAL EXPOSITION of Power and Mechanical Engineering will hold its 13th exhibit Dec. 5 to 10 in Grand Central Palace, New York City, the last one being held in 1936, with attendance of 38,943. A large percentage of the exhibit space on three floors is already engaged by manufacturers who have had exhibits at previous shows. As heretofore, management will be directed by Charles F. Roth, president.

SINCE THE suspension of the Government schedule for bituminous coal prices, operators from the eight producing districts of southern high volatile field have agreed to sell most of their tonnage through Appalachian Coals, Inc., in order to "prevent a prolonged price war." This agreement will cover some 72 to 75 per cent of the tonnage of that field, possibly later as much as 85 per cent.

Technical Publishing Co. Elects New Officers

REARRANGEMENT of the personnel of Technical Publishing Co., publisher of POWER PLANT ENGINEERING, made necessary by the death of Edward R. Shaw, late president of the Company, has been completed by the purchase of all stock by the remaining stockholders and the election of officers as follows: Chairman of the Board of Directors, Arthur L. Rice; President, Kingsley L. Rice; Vice President and Advertising Manager, Walter Painter; Vice President, Research and Circulation Manager, Edwin C. Prouty; Treasurer, Arthur L. Rice; Secretary, Charles S. Clarke; Directors, Arthur L. Rice, Kingsley L. Rice, Charles S. Clarke, Ralph E. Turner. The Editorial staff will be: Editorial Director, Arthur L. Rice; Editor, Ralph E. Turner; Electrical Editor, Andrew W. Kramer; Engineering Editor, Richard H. Morris. Field representatives will be as heretofore, John A. Kershaw, New York; George D. Lounsbery, Philadelphia; George E. Andrews, Cleveland; Charles S. Clarke, Chicago. Home office is at 53 W. Jackson Blvd., Chicago, Ill. John O. Aarvold will be Production Manager; and Otto Kaad, Mechanical Superintendent.

No changes are contemplated in editorial or publication standards of practice; the continued aim of the entire organization will be to have POWER PLANT ENGINEERING give the best possible service to its readers and to manufacturers who advertise in its pages.

First Annual Anthracite Conference

DR. C. C. WILLIAMS, president of Lehigh University, recently announced that the first Anthracite Conference will be held under university auspices on April 29 and 30. It is expected to become an annual affair to survey engineering developments in the mining and utilization of Anthracite.

According to the conference chairman, Dr. Herman Eckfeldt, professor of mining engineering at Lehigh, 18 technical papers are to be presented in the two-day conference. The subjects and authors are as follows: Pennsylania Anthracite Reserves, by Dr. Geo. H. Ashley; Inherent Characteristics of Anthracite, by Dr. H. J. Rose; A Resume of the Non-Fuel Uses of Anthracite, by Professor H. G. Turner; A New Theory Concerning the Combustion of Anthracite, by E. S. Sinkins; Some Practical Considerations in Connection with Combustion, by A. J. Johnson; The Application of Thermostatic Controls to Various Types of Anthracite Equipment, by Arnold Michelson; Magazine or Self-Feeding Boilers for Coal, by Wm. Anderson; Domestic Burners (or Stokers) for Anthracite, by P. A. Mulcey; An Improved Method of Hand Firing Pennsylvania Anthracite in Commercial Installations, by H. J. Littell; Air Conditioning and Refrigeration, by B. H. Jennings; Equipment for the Use of Anthracite in Apartment Houses and Semi-Industrial Purposes, by Wm. Stein; The Pulverization of Anthracite for Commercial Use, by Martin Frish; Anthracite for Power Generation, by H. W. Warren; The Distribution of Anthracite, by A. Haring; Domestic Ash Handling, by E. T. Selig, Jr.; The Use of the Degree-Day Calculations in the Retail Coal Industry, by A. F. Duemler; The Relation of the Type of Fuel to the Cleanliness of Communities, by W. G. Christy; Statistical Analysis of the Growth of Pennsylania Anthracite, by E. C. Bratt.

At the conclusion of the conference these papers will be published in a single report which will be made available for general references.

Accommodation and registration has been made available through the office of the Anthracite Conference, Packard Laboratory, Lehigh University, Bethlehem, Pa.

Prices on G-E Capacitors Reduced Up to 18 Per Cent

PRICE REDUCTIONS of as much as 18 per cent on capacitors depending on ratings of the units have been announced by the General Electric Company. Price of the 2300-v., 15-kv-a. capacitor has been reduced ten per cent, while an 18 per cent reduction has been effected in the prices of the 4600-v. and 6900-v., 15 kv-a. units.

This reduction brings the average price of capacitors to less than 40 per cent of their 1929 level and is another in a series of price reductions in the G-E capacitor line effected through improved manufacturing methods and the use of new and improved materials over the past 9 yrs.

A comparable reduction in size and weight of G-E capacitors has also been effected since 1929. The 1929 2300-v., 15-kv-a. equipment weighed 135 lbs., whereas today's capacitor of the same rating weighs but 47 lbs. Responsible for this reduction are such refinements as an improved paper di-electric, and the use of Pyranol in the units. Pyranol, a non-inflammable, non-explosive liquid dielectric with exceptionally high insulating qualities, was first used in capacitors in 1932 by General Electric. Its use alone made possible a substantial contribution to the reduced size and weight of G-E capacitors.

Midwest Power Conference

SPONSORED by Armour Institute of Technology in cooperation with Iowa State College, Purdue University, State University of Iowa, University of Illinois, University of Michigan and University of Wisconsin; also with the cooperation of local and national engineering societies, the Midwest Power Conference will meet in Chicago April 13-15 with headquarters at the LaSalle Hotel. This conference, reorganized under the academic sponsorship to provide the freest possible discussion of the technical, economic, and social implications of power usage, will be open to all persons interested in the solution of the nation's power problems.

After several papers of general interest at the opening session, a number of technical conferences will be held at which specific problems will be discussed.

Wednesday afternoon, April 13, will be devoted to three conferences on: 1, Fuels; 2, Trends in electric power equipment and, 3, Locomotive power units. The conferences on Thursday morning, April 14, will include 1, Developments in Stationary power plants; 2, Power measurements and, 3, Valuation of power plants. Thursday afternoon, April 14, will be devoted to a study of 1, Metals, 2, Problems in the operation of power plants, and 3, Hydro power.

Many men who have attained prominence in this field are scheduled to be heard at the Conferences. They include: H. T. Heald, A. A. Potter, C. F. Hirshfeld, Philip Swain, Ralph A. Sherman, W. B. Walraven, F. W. Godwin, Edward Bennett, W. E. Blowney, J. H. Cox, O. K. Marti, F. H. Prescott, A. L. Rice, G. A. Hawkins, F. H. Rosencrants, M. P. Cleghorn, Royce E. Johnson, M. J. Zucrow, T. R. Agg, E. B. Kurtz, C. F. Harding, H. C. Anderson, W. S. Monroe, Frank F. Fowle, W. A. Pearl, A. E. White, J. P. Magos, F. R. Zenton, F. T. Mavis, M. K. Drewry, J. M. Drabelle, Grover C. Neff, F. M. Dawson, E. W. Lane, A. V. Karpov, James D. Cunningham, H. O. Croft, A. P. Kratz.

The special program arranged for Friday, April 15, includes an inspection trip to Armour Institute of Technology where two papers on "Heat Energy Costs or B.t.u. Auditing" and "Power Requirements for Residential Air Conditioning" will be presented. This will be followed by an inspection of the high pressure laboratory where Dr. T. C. Poulter has reached the record-breaking pressure of one and one-half million pounds per square inch. After luncheon on the campus, the group will be transported by the Carnegie-Illinois Co. to its plants where a new power installation and new steel manufacturing equipment will be inspected.

The entertainment at the Midwest Power Conference will include a buffet luncheon and an evening smoker the first day, a luncheon for electrical and mechanical groups on the second day which will be followed by the banquet on the evening of the second day. Complete information can be obtained by addressing L. E. Grinter, Dean of the Graduate School at Armour Institute of Technology, who will act as director of the conference.

William Herbert Thomas

AFTER A FIVE WEEKS illness of pneumonia, William Herbert Thomas passed away at his home in Syracuse, N. Y., in the latter part of February. He was born in Warners, N. Y., 68 yr. ago, coming to Syracuse when 15 yr. old and advancing to industrial and financial prominence. For 50 yr. he had been associated with Straight Line Engine Co. and Direct Separator Co., the last 25 years as president of these companies. His interest in the advancement of industry was shown by his activities in the Technology Club, the American Foundrymen's Assn. and National Metal Trades Assn.

In later years he became associated with banking interests as director of City Bank for several years and, after merger with the First Trust and Deposit Co., as director of that institution.

His interest in social and church activity was indicated by his membership in Central City Scottish Rite, the Scottish Rite Club, Tigris Temple, AAONMS and Good Will Congregational Church.

Surviving are his wife, Ina Wallace Thomas, and two sons Walter Herbert Thomas and Wallace Edgar Thomas, who have been associated with him in The Direct Separator Co., Inc.

Mr. Thomas was always sturdy in adherance to his belief in correct principles of engineering and merchandising in the development of the Straight Line Engine and the Direct Separator, and he will be gratefully remembered by those who were fortunate enough to receive his friendship and good counsel.

Lewis M. Parsons

MR. PARSONS has recently been elected vice-president in charge of sales, also a director of Jones & Laughlin Steel Corp., Pittsburgh. After graduation from University of Pennsylvania in 1917, he served in the destroyer service and in the flying corps of the U. S. Navy during the world war,

Lewis M. Parsons

then joined the sales division of Bethlehem Steel Co. He rose to assistant manager of sales, Philadelphia office, in 1932, and to sales manager in 1936. He will now have entire charge of all sales activities, sales offices and warehouses of Jones & Laughlin.

G. Sinding-Larsen

PITTSBURGH PIPING AND EQUIPMENT Co., Pittsburgh, Pa., announces the appointment of G. Sinding-Larsen as Chief Engineer. As a native of Norway, Mr. Sinding-Larsen received his engineering education at the Technical College of Oslo, from which he graduated in 1912 with a degree of M.E. His early practical training included hydraulic turbine engineering work and development engineering for the Norwegian State Railways. Coming to America in 1921 he gained widespread experience in all phases of power and process piping with J. G. White Co., Consolidated Edison Co. of New York, and Sanderson and Porter Co., consulting engineers. In 1924 Mr. Sinding-Larsen joined the engineering department of Pittsburgh Piping and Equipment Co. where he has been active in the research and development of creased bends and corrugated pipe and their application to steam lines and central station design.

G. Sinding-Larsen

New Allis-Chalmers Erection Superintendent

LEON A. WATTS has been appointed to succeed the late Samuel Moore as General Superintendent of Allis-Chalmers Mfg. Co's service and erecting department. He joined that company in 1903 and since 1935 has acted as assistant to Mr. Moore, whom he now succeeds.

Leon A. Watts

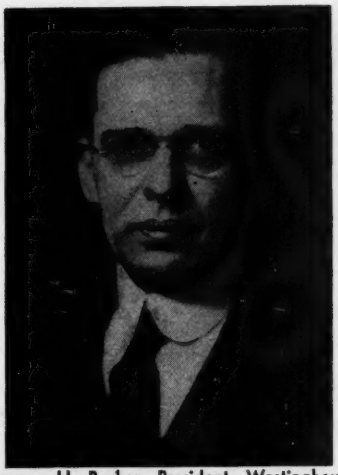
Mr. Watts was born in southwest Texas, attended the public schools in Austin, and later served time aboard ship in the mechanical and electrical branch of the service. For several years he gained operating experience in connection with steam and hydro-plants in various parts of the country. At the World's Fair in St. Louis in 1903, this included "Old Reliable", engine driven generating unit built by the Bullock Electric Company and Allis-Chalmers, and which then was the largest unit of its kind in the world. Various phases of his work have carried him into every state of the union and to many foreign countries.

Westinghouse Elects George Bucher President

GEORGE H. BUCHER, Executive Vice President of the Westinghouse Electric & Mfg. Co., has been elected President of the company.

Frank A. Merrick, President since 1929, was elected Vice Chairman. The announcement was made by A. W. Robertson, Chairman, following a meeting of the Board of Directors at the company's New York offices.

Paul Judson Myler, President of the Canadian Westinghouse Co., became a Director of the Westinghouse Electric & Mfg. Co. at the same meeting.

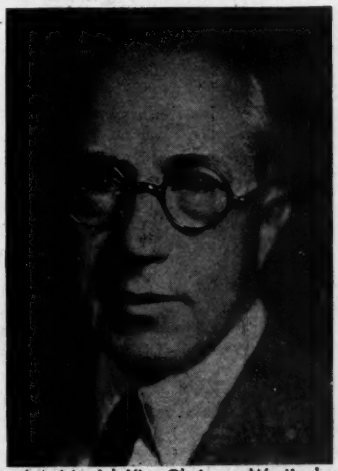


George H. Bucher, President, Westinghouse Electric & Mfg. Co.

Mr. Bucher and Mr. Merrick have both been with the Westinghouse Co. for many years. As a member of the graduate students' training course, Mr. Bucher, who today became President, began his work with the company on September 1, 1909, in an assembly aisle at the East Pittsburgh plant.

Born in Sunbury, Pa., Mr. Bucher was graduated from the high school there before he entered Pratt Institute, Brooklyn, to study machine design and electrical engineering. His first job was with the Westinghouse Electric & Mfg. Co.

In 1920 he was appointed assistant to General Manager of the Westinghouse Electric International Co., and a year later, 1921, Assistant General Manager. This position he held until 1932, when he was elected Vice President and General Manager.



Frank A. Merrick, Vice-Chairman, Westinghouse Electric & Mfg. Co.

1934 brought further progress in his career; he was elected President and General Manager of the International Company. The following year he became a Vice President of the parent company, the Westinghouse Electric & Mfg. Co. In 1937 he was named Executive Vice President and a Director of the parent company.

Mr. Merrick, elected Vice Chairman, was born in Lambertville, N. J., and educated in electrical engineering at Lehigh University, where he was graduated in 1891. In the same year, he entered the employ of the Thomson-Houston Electric Company; served successively as a consultant with the engineering firm of Blood & Hale, manager and chief engineer of the Steel Motor Company. When the Steel Motor Company was absorbed by the Westinghouse Electric & Mfg. Co. in 1902, Westinghouse officials considered that Mr. Merrick was one of the principal assets acquired in the deal.

When the Canadian Westinghouse Company, Ltd., was formed the following year, he had charge of construction of its plant at Hamilton, Ontario. He remained there as superintendent and later became, successively, manager, vice president, general manager and director.

For two years after the war Mr. Merrick was located in London, as special representative of the company. He then returned to his duties in Canada. In 1925 he became Vice President and General Manager of the Westinghouse Electric & Mfg. Co., with offices at East Pittsburgh. Four years later, in June, 1929, he was elected President.

Mr. Myler, new member of Westinghouse's Board of Directors, has also long been associated with Westinghouse interests. Born in Pittsburgh, he entered the employ of the Westinghouse Air Brake Company in 1886; became Secretary of the Westinghouse Manufacturing Company of Canada in 1896, and Vice President of the Canadian Westinghouse Company in 1903. He was elected President of the Canadian company in 1917.

Sargent & Lundy, Inc.

SARGENT & LUNDY, INC. of Chicago one of, if not the oldest and best known firm of power plant engineers in the country recently elected Bernhard Schroeder, formerly vice president and chief engineer, president and Ludwig Skog, formerly chief mechanical engineer, vice president. Mr. Schroeder succeeds William S. Monroe who for nearly half a century has been closely identified with the power field and who will remain as a director and in an advisory capacity. Following his graduation from Cornell in 1890, Mr. Monroe joined the Mechanical Engineering department of the first Chicago World's Fair and worked on the design of the power plant. In 1900 he joined Sargent & Lundy as chief draftsman and for many years has been president. Mr. Skog, who was educated in Norway, joined Sargent & Lundy in 1910.

Cochrane Corp. President

PERCY S. LYON was elected President of the Cochrane Corp., Philadelphia, Pa., at the monthly meeting of the Cochrane board, March 1. Mr. Lyon, who had been assistant to the president of the company since January 1, succeeded Eugene Clark, whose retirement from the presidency was announced.

Mr. Lyon, who was graduated with the degree of mechanical engineer from Cornell University in 1912, has been associated with the Cochrane Corporation 18 yrs., the first sixteen of which immediately followed his graduation from Cornell. He was granted a leave of absence during the World War, when he served as a captain at the artillery school,

Percy S. Lyon

Fort Monroe, Va. After the war he rose to the rank of lieutenant-colonel in the coast artillery reserve. From 1921 to 1928 he was chief engineer of the Cochrane Corporation. That year he became chief engineer of the Hall Electric Manufacturing Co., Philadelphia, and in 1932 he joined the General Electric Company in commercial engineering work in New York. In 1936 he rejoined the Cochrane "family" with the Turbine Equipment Co., Cochrane representatives in the New York territory.

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Refractories and Insulating Materials

Furnace Construction—Development of furnace construction during the last 25 yr. and the latest construction of arches and walls for all types of furnaces, for all kinds of fuels, illustrated by drawings, dimensions and photographs are treated in a 64-p. book, printed in three colors. Construction of incinerators, cracking stills, steel treating and metallurgical furnaces is included. Copies may be had from E. H. Detrick Co., 140 So. Dearborn St., Chicago, Ill.

Properties of Ceramic Insulating Materials of the American Lava Corporation are shown on a chart which has just been published by that company. The data presented on this chart is very complete and should be extremely useful in selecting insulating materials for specific purposes. Copies of this chart may be obtained from the American Lava Corp., Chattanooga, Tenn.

Insulating brick—In an 8-p. bulletin are described the advantages from use of Insulbrix and its characteristics of light weight, low heat storage and efficient insulation, as used for direct exposure to flame and gases, in boiler furnaces, ovens, kilns and other high

temperature equipment, to save fuel, time, labor and operating cost. Quigley Co., Inc., 56 W. 45th St., New York, N. Y.

Ehrets 85 per cent Magnesia is the subject of a new catalog. The first few pages are devoted to a brief general description of the physical properties and insulating characteristics of various heat insulating materials. The remaining pages describe and illustrate the product mentioned in the subject, namely Ehrets 85 per cent magnesia. Ehret Magnesia Mfg. Co., Valley Forge, Pa.

Research for Ceramic Industries is the subject of a catalog prepared for the purpose of showing how the Battelle Memorial Institute can assist industry. It includes more than 30 pictures. Battelle Memorial Institute, 505 King Ave., Columbus, Ohio.

Clinker-Proof Long Life Furnace Walls is the subject of a new bulletin, B-344, issued by the Bernitz Furnace Appliance Co., 89 Broad Street, Boston, Mass.

Water Treatment, Controls Meters and Instruments

Organite, a water treatment for the control of water, brines and commercial processes is the subject of a pamphlet of the Organite Co. of Illinois, 2350 W. Van Buren St., Chicago, Ill.

Poor Flow of Water is the title of a new bulletin which discusses the clogging action of rust deposits in water pipes and describes means for removing the restrictions and improving the flow of water. Water Service Laboratories, Inc., 423 West 126th St., New York, N. Y.

Megger Insulation Testing Instruments, a new 40-page catalog, No. 1550, under this title describes a complete line of instruments for measuring insulation resistance. It includes types and ratings that meet practically all demands in the electrical industry for portable instruments for that purpose. James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa.

Fulton Gas Regulators—This 1938 catalog includes many of the various types of gas pressure regulators made by the manufacturer. The types shown cover all ordinary forms of service, both for natural and manufactured gas. The Chaplin-Fulton Mfg. Co., 28-40 Penn Avenue, Pittsburgh, Pa.

Brown Hygrometers.—This new catalog (No. 6502) covers the complete line of Brown recording and controlling hair hygrometers. Both electrically operated and air-operated humidity controllers (psychrometer type) are described. The latest additions to the Brown hygrometer line are illustrated in the catalog. The Brown Instrument Co., Wayne & Roberts Avenues, Philadelphia, Pa.

Regulators.—Types for control of pressure, pump operation. temperature, combustion, superheat, with valves operated either by pressure or electricity are described, illustrated and dimensions and capacities tabulated in an attractive 20-p. catalog of Spence Regulators. A steam-atomizing desuperheater is a novel feature, also a convenient chart for calculating the flow of gases through pipes. Issued by Spence Engineering Co., Inc., 75 West St., New York, N. Y.

Standco Speed Indicator, or as it is sometimes referred to chronometric type tachometer, is described and illustrated in Bulletin No. 715. The instrument is an accurate type of portable or hand speed measuring device. Herman H. Sticht & Co., 27 Park Place, New York, N. Y.

Process Steam Savings—Use of a recording flow meter for steam, used in departments, is discussed in a folder of The Brown Instrument Co., Wayne and Roberts Aves., Philadelphia, Pa.

Diesel Engines and Electrical Equipment

Diesel Engine — Features of new model, also discussion of applications of Diesel engines and recent developments are given in February issue of Baldwin-Southwark magazine. Other features are the work of forest products laboratories and the Loup River hydro-electric plant. Baldwin-Southwark Corp., Philadelphia, Pa.

Diesel Pyrometers are briefly discussed in Bulletin 40. Three different types are described and illustrated. Additional information is given concerning Diesel engine thermocouples. Wheelco Instruments Co., 1929-33 S. Halsted St., Chicago, Ill.

Kompak air filter having variable velocity from 25 to 36 f.p.m., a 15 to 1 ratio of filtering medium to face area, low refill cost, high cleaning efficiency and other unique features is described in bulletin No. K-120 of the Independence Air Filter Co., Inc., 228 N. LaSalle St., Chicago, Ill.

Portable Electric Tools, such as shorty drill, utility power drills, lectro-shears, tapper, screw drivers, nut runners, trim saws, portable grinders, two-speed sanders and combination sander-polisher are illustrated in a new catalog under this title. Improvements in design and construction have been incorporated into a number of the old line tools. The Van Dorn Electric Tool Co., Towson, Md.

S&C Type SM Fuses for heavy-duty current-interrupting service are described in Bulletin 200-E. It describes the functions, construction and operation of these fuses, and includes illustrations of the product and a number of applications. A diagrammatic sketch, also included, shows the details of the refill unit which is a part of this new fuse. Complete dimensional and capacity data for the fuse holders, mountings and units complete the bulletin. Schweitzer & Conrad, Inc., 4435 Ravenswood Ave., Chicago, Ill.

Solution of Electrical Networks by Successive Approximations is the title of Bulletin No. 229 of the Engineering Experiment Station of the University of Illinois. This bulletin prepared by Lawrence L. Smith, associate in Electrical Engineering, describes an interesting method for the mathematical solution of electrical networks. As pointed out by the author, various methods of attack have been devised for obtaining the solution of electrical networks, i.e., by the use of calculating tables, by the method of simultaneous equations, by the method of trial and error, but this bulletin presents still another method of solving these networks.

Although the method of successive approximations might be considered a trial-and-error, or "cut-and-try" method it is sufficiently different to warrant a separate classification. The methods discussed differ from a strict "cut-and-try" method in that, after the first assumption of values, the method leads very definitely and surely to the correct solution, without further exercise of judgment in making new assumptions.

The method as presented is applied to a.c. and d.c. power networks, but it is applicable to any network composed of invariable parameters which are constant with respect to time.

Until Aug. 15, 1938, or until the supply available for free distribution is exhausted, copies of this bulletin may be obtained without charge upon application to the Engineering Experiment Station, Urbana, Ill.

Flame-otrol, an electronic device for protecting gas fired boiler against explosions due to loss of ignition, now furnished in a new flush mounting is described and illustrated in Bulletin 1102 of the Wheelco Instruments Co., 1929 South Halsted St., Chicago, Ill.

New Profits from Resistance Welding with Ignitron Split-Second Control.—A 12-page pamphlet under this title includes illustrations of actual installations of ignitron controls for fabricating large and small parts; also, typical parts and products of steel, stainless steel, aluminum and other metals and alloys welded on a production basis are shown. Ignitron controls are available for spot, seam, butt and projection welding operations, and for applications requiring a single welder for both spot or seam welding. Suggestions for handling unusual welding jobs needing frequent heat adjustment, or different current and time values are discussed in this booklet. Copies may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Electrical Equipment—Ten new publications describe the following subjects: GEA-288A, CR9194 Autotransformers; GEA-2545, A-C and D-C equipment for traveling electric cranes; GEA-2606, Automatic control for schoolroom lighting; GEA-2011A, Hire Inspector AP-9; GEA-1587C, Combination Magnetic Switch; GEA-2473, Push-button stations; GEA-2516, Here are the five keys to control problems; GEA-1884A, Multi-speed Induction Motors; GEA-2635, Recording Instruments. General Electric Co., Schnectady, N. Y.

Electric Rates—Report for 1937 of electric rates in cities of 50,000 population or more, with typical monthly bills for electric service, records of increases and decreases in rates and comparisons of rates in various cities are given in the 52-p. report of the Federal Power Commission, 1937 Rate Series A. Copies may be had from Superintendent of Documents, Washington, D. C. Price Fifteen Cents.

Motor Generator Sets, illustrated and described in Bulletin 1155A, provide a flexible and convenient method of converting electrical energy from one form to another, when the conversion involves changes other than a.c. voltage transformation. Methods of conversions covered by the bulletin fall into three general classes: 1, Conversion

from a.c. to d.c. or vice versa; 2, Conversion from a.c. to a.c. at a different frequency; 3, Conversion from d.c. to d.c. at a different voltage. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Diesel-Electric Generator — Wide range of uses for Diesel powered electric generator sets are cited in a new booklet, illustrating plants for villages, municipalities, construction work, mining and industrial and manufacturing. In addition, the booklet gives the listed ratings of the eight sizes of Caterpillar powered generator sets now available, ranging in size from 80 to 20 kw. Copies of this new booklet can be obtained by writing Caterpillar Tractor Co., Peoria, Ill., for form No. 4658.

Electro-Plating — Portable electroplating outfit for finishing any part of a machine in place is described in a 4-p. folder of W. A. Hesse & Co., 1015 Santa Clara Ave., Alameda, Calif.

Rectox Rectifiers—A 12-page illustrated pamphlet has been prepared which shows how this direct-current rectifier of simple design and sturdy construction opens up wide possibilities for design of new products and improvement of old designs. The booklet outlines the various characteristics of Rectox Rectifiers, gives a list of applications and points out advantages. Copies may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Piping

500 Brinell—A new catalog under this title describes and illustrates Hancock's complete line of bronze valves. Particularly featured is the line of Hancock supervalves with the nail-smashing hardened stainless steel seats and discs. Copies will be furnished on request by Hancock Valve Division of Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

The Dexter Valve Reseating Machines are illustrated and described in a new catalog, No. 24. It is divided into three parts, the first part treating globe valve reseating machine, part two, the gate valve reseating machine and part three pump valve reseating machine. The Leavitt Machine Co., Orange, Mass.

Related Instruction for Plumber Apprentices—Tentative subjects of the National Committee on Apprentice training in the plumbing industry have been prepared by United States Department of Interior, Office of Education, Vocational Education, Washington, D. C.

American Seamless Flexible Metal Tubing—Bulletin SS-3 gives facts and data relative to the manufacture and application of this particular type of flexible metal tubing which is made without seams, joints, laps, welds or packing of any kind. American Brass Co., American Metal Hose Branch, Waterbury, Conn.

Tube Cleaners—A new 32-page catalog divided into two parts—one, devoted to a description of the design and development of this equipment, the other illustrating the complete line of Roto cleaners and accessories. The Roto Company, Newark, N. J.

Bearings and Lubrication

Official driving tests, conducted by the American Automobile Association contest board. Official AAA drivers in 1935 Ford, Chevrolet and Plymouth stock cars, purchased by the contest board, were driven a total of 21,000 miles on Roosevelt Raceway, Long Island. Four makes of piston rings from dealers stocks were used in the cars to test their ability in controlling oil consumption. These tests cover a total mileage equivalent to seven-eighths of the distance around the world, in order to test the oil conserving ability of its new flexible Oil Cutter piston ring in competition with other makes are described in a 24-page booklet just published by Koppers Co.'s American Hammered Piston Ring Division, Baltimore, Md.

Bearings—Sleeve bearings for all purposes, in all sizes and in various materials, also bearing materials are tabulated and illustrated in a 64-p. catalog of Johnson Bronze Co., New Castle, Pa.

Oilite Bearing—A pocket size catalog under this title gives a short description of the product, price list and application. Boston Gear Wks., Inc., North Quincy, Mass.

Pumps

Pump Lubrication—Relation of pumping operations to lubrication for plunger pumps, rotary mechanisms and driving mechanisms, also the advantages of pressure circulation of lubricant, lubrication of heavy duty pumps and of sleeve, roller and ball bearings is fully treated in the March issue of Lubrication issued by The Texas Co., 135 East 42nd St., New York, N. Y.

East Park Pumping Station of the City of Philadelphia, is described and illustrated in a leaflet reprinted from Power Plant Engineering and being distributed by De Laval Steam Turbine Co., Trenton, N. J.

Miscellaneous

An indexed list of the engineering and industrial standards and safety codes of the association, complete to February 1, 1938, is now available from the American Standards Association, 29 West 39th St., New York, N. Y.

Wire Rope—Two new catalogs, one entitled Wire Ropes Natural Enemies, gives nine factors which have harmful effects on wire rope. The other is entitled Greater Dollar Value with Tru-lay Preformed, giving the qualities of this particular product. Copies of these two catalogs may be had on request to American Cable Div. of the American Chain and Cable Co., Inc., Wilkes-Barre, Pa.

Clerex—A new product which apparently fills a long felt need in the prevention of sludge, gum, rusting and pitting in fuel oil heating systems. In addition, smoking, plugging of valves and pipings, sludge and carbonizing in the heater, carbon in the burner and clogging of the oil burner strainer are eliminated. It is described in a folder issued by Magnus Chemical Co., Inc., Garwood, N. J.

Safety Hoist — Lever action hoists with safety stops to hold in any position, push-button reverse action and overload safeguard, for capacities from ¾ to 15 t. are described in a folder of Coffing Hoist Co., Danville, Ill.

Care and Operation of Enco Oil Burning Equipment is the subject of a 44-page booklet written by Kingsley L. Martin. It discusses the relative merits of the Steam and Mechanical Atomizing Burners under various conditions and gives directions for getting rid of unburned oil in the furnace. It may be had on request to The Engineer Co., 17 Battery Place, New York, N. Y.

Marine Steam Turbine—Story of the trial trip of the Esso Bayonne, a turbine-driven tanker of Standard Oil Co., well illustrated and told in an interesting way by Felix Riesenberg, with dimensions of the ship and results of trials. De Laval Steam Turbine Co., Trenton, N. J.

Eye Protection—Specifying types of safety goggles to wear for protection against eye hazards in all principal industries is a chart completed by the Safety Engineering division of American Optical Co., Southbridge, Mass., which will be sent on request to any industrial concern.

Johns-Manville Annual Report — A simply-worded, illustrated financial report for the year 1937, made by President Lewis H. Brown, to job holders and stockholders. It gives a picture of the growth of the company's business, shows in what ways money received for products was expended for raw materials, wages, taxes, depreciation, research and returns to stockholders. It compares these receipts and expenditures over a 10-yr. period and shows the amount furnished by stockholders to give an investment of $4561 per worker to provide employment. A brief history of the company traces its growth from a family-owned business to its present ownership by 7138 stockholders.

Mr. Brown explains that, "This report will give all J-M jobholders a record of our company's progress during the last year, our prospects for continued progress and some of the economic problems jobholders will face together with management and stockholders in 1938. Stockholders put in their money and, when business is good, are paid 'dividends,' but when business is bad they are 'laid off' in that they receive reduced or no dividends. Jobholders put their work into the company. When business is good they receive regular pay and opportunity to earn more. If business conditions force the company to slow down, some jobholders have to be 'laid off,' in that hours may be reduced, pay may be cut or actual lay-offs may be necessary.

"It is the chief concern of management to try to plan for the best possible, uninterrupted annual returns for both jobholder and stockholder, so that neither will have to be 'laid off.' Stockholders and jobholders are dependent upon each other, and neither can profit without the support and coöperation of the other."

The report is an excellent example of taking workers into the confidence of the company and may well serve as a model for other employers to follow. Johns-Manville, 22 E. 40th St., New York, N. Y.

Power Plant Construction News

Calif., Colton—Community Meat Packing Plant, Highland, Calif., Henry Sieck, head, plans installation of electric power equipment in new branch plant in vicinity of Colton, where site has been acquired. It will be 100 x 100 ft. Entire project will cost about $55,000.

Ill., Westmont—Jordan Co., 2630 West Arthington St., Chicago, Ill., plans installation of electric power equipment in new chemical-manufacturing plant in vicinity of Westmont, where site has been acquired. It will comprise group of about 14 buildings. Entire project will cost close to $300,000. Proposed to ask bids on general erection at early date. N. Ronneberg, Inc., 10 South LaSalle St., Chicago, is consulting engineer.

Ind., Evansville—Board of School Trustees, Seventh and Vine Sts., will take bids soon for a one-story boiler plant in connection with new vocational school unit at Wedeking Avenue and Stringtown Road, for which bids will be asked at same time. Entire project will cost about $250,000. Fowler & Legeman, Central Union Bank Building, Evansville, are architects.

Ind., Huntington—Board of School Trustees, H. A. Buzzard, Secretary, is considering construction of new steam power house at central school for central heating service. Cost close to $50,000, with boilers and auxiliary equipment. Financing is being arranged.

Ind., Richmond—Johns-Manville Corporation, 22 East 40th St., New York, N. Y., plans installation of electric power equipment in new one-story addition to fiber conduit plant at Richmond, for which superstructure will begin soon. Cost about $70,000.

Iowa, Clinton—E. I. duPont de-Nemours & Co., Inc., duPont Building, Wilmington, Del., Cellophane Division, will install electric power equipment in new mill at Clinton, where large tract of land recently was acquired. Plant will consist of several production units. A power house will be built for mill service. Entire project will cost over $5,000,000. Work is scheduled to begin soon. Company engineering department is in charge.

Iowa, Fort Dodge—S. M. McNamara, 400 National Building, Minneapolis, Minn., is at head of project to construct and operate an ice-manufacturing plant at Fort Dodge, where site has been secured. Plant will have an initial capacity of about 20 tons per day. Cost about $35,000, with equipment.

Ky., Ashland—City Council, John Kobs, city manager, plans installation of pumping machinery and auxiliary equipment at municipal water-works station for increased plant capacity. Also will install transformers and other electrical apparatus. Entire project will cost about $150,000. Barstow & LeFeber, Inc., American Building, Cincinnati, Ohio, is consulting engineer.

La., Bossier City—City Council plans new municipal electric light and power plant, and electrical distributing system. Also a natural gas distributing system and control station. Entire project will cost about $350,000. A special election has been called April 5 to approve bonds in that amount.

La., Breaux Bridge—Breaux Bridge Sugar Co-Operative, Inc., plans installation of electric power equipment in new cane sugar mill on local site. A power house will be built for mill service. Entire project will cost over $175,000. Work is scheduled to begin soon. E. A. Rose, 816 Howard Ave., New Orleans, La., is engineer. Stanley Angelle is secretary.

Mich., Dowagiac—City Council has plans maturing for expansion and improvements in municipal electric power plant and electrical distribution system. Cost estimated close to $200,000. Ayres, Lewis, Norris & May, Ann Arbor, Mich., are consulting engineers.

Minn., Cambridge—City Council is considering new municipal electric light and power plant, and proposes to have surveys and estimates of cost made at early date. Tentative estimates place cost at close to $115,000, with engine-generator units and accessories.

Minn., Virginia—Municipal Utility Commission, M. C. Bright, superintendent, plans extensions in municipal steam-heating system, including installation of pipe lines, control facilities, etc. Cost about $120,000. Surveys and detailed estimate of cost will be made soon.

Miss., Natchez—Armstrong Rubber Co., West Haven, Conn., plans installation of electric power equipment in new automobile tire manufacturing plant at Natchez where arrangements have been made with city for erection of buildings to cost about $300,000. A power house will be built. Plant output will be used by Sears, Roebuck & Co., Arthington Avenue, Chicago, Ill., which will be active in project. Complete mill will cost over $1,500,000. Robert & Co., Bona Allen Building, Atlanta, Ga., are architects.

Miss., Vicksburg—Marquette Cement Mfg. Co., 140 South Dearborn St., Chicago, Ill., plans installation of electric power equipment in new cement terminal plant at Vicksburg. Mechanical-handling equipment also will be installed. Entire project will cost about $250,000. Company engineering department is in charge.

Mo., St. Louis—Anheuser-Busch, Inc., 721 Pestalozzi St., has filed plans for extensions and improvements in power house at brewery, and will proceed with work soon. Cost estimated close to $70,000, with equipment.

Mont., Polson—Missouri Irrigation District, Polson, G. A. Lensman, commissioner, plans large pumping plant for increased water supply for district. Site is being selected near Polson. Cost about $500,000, including pipe line facilities.

Neb., Grand Island—Additions to municipal power plant as listed in the March issue to be corrected as follows: Cost of work contemplated in the neighborhood of $350,000, includes building and machinery and will be financed from the lighting fund. Plant will be operated on 425 lb. steam pressure, 750 deg. F. total temperature, one additional boiler and turbine of 4000 or 5000 kw., to be decided later. Mr. C. W. Burdick, Commissioner in charge, C. T. Minnich, Operating Superintendent.

Neb., Omaha—Wilson & Co., Union Stock Yards, Chicago, Ill., plan installation of electric power equipment in connection with additions and improvements in branch meat-packing plant at 27th and Y Sts., Omaha, formerly the property of Dold Packing Co., recently acquired. Entire project will cost close to $300,000. John Latenser & Sons, Inc., Saunders-Kennedy Building, Omaha, Neb., is architect.

N. J., Gloucester City—Sherwin-Williams Co., 101 Prospect Ave., N. W., Cleveland, Ohio, manufacturer of paints and varnishes, plans installation of power equipment in new paint pigment plant at Gloucester City, where company has acquired property formerly occupied by the Pusey & Jones Co., idle for many years. New buildings will be erected. Entire project will cost close to $500,000.

N. Y., Long Island City—New York & Queens Electric Light & Power Co., 28-19 Bridge Plaza, Long Island City, a subsidiary of Consolidated Edison Co. of New York, Inc., 15 Irving Place, New York, plans expansion and improvements in power plants and system in 1938 to cost about $3,000,000. Fund is being arranged through a new $10,000,000 bond issue.

N. Y., Oswego—Niagara Hudson Power Corporation, Electric Building, Buffalo, N. Y., has plans nearing completion for proposed steam-electric generating plant at Oswego, and will begin work on project soon. Extensions will be made in transmission lines in that area. Entire project will cost over $3,000,000.

Ohio, Cleveland—Cleveland Pneumatic Tool Co., 3734 East 78th St., plans installation of electric power equipment in new two-story top addition to plant, 54 x 180 ft. Entire project will cost over $60,000. Work is scheduled to begin soon. Ernest McGeorge, 9400 Quincy Ave., Cleveland, is engineer.

Okla., Oklahoma City—Terminal Oil Mill Co., 5 East Frisco Ave., plans installation of electtic power equipment in connection with rebuilding of portion of cottonseed oil mill, recently destroyed by fire. Loss estimated close to $100,000. G. T. Davenport is manager.

S. D., Flandreau—Common Council is concluding arrangements for purchase of local electric power plant of Union Publie Service Co., and will operate as municipal property in future. Plans are under way for improvements in station, including installation of two new engine units and auxiliary equipment. Financing is being arranged through Federal aid. Buell & Winter Engineering Co., Insurance Exchange Building, Sioux City, Iowa, is consulting engineer.

Texas, Electra—City Council has plans under way for new municipal electric power plant and electrical distributing system. Cost about $220,000. Financing is being arranged in part through Federal aid. Joseph E. Ward, Harvey-Snider Bldg., Wichita Falls, Tex., is consulting engineer.

Texas, Houston—Houston Lighting & Power Co., has authorized expansion and improvements in steam-electric generating station on Gable Street, with installation of new 25,000-kw. turbo-generator unit, high-pressure boilers and auxiliary equipment. Work will be started in 1938 and completed in 1939. Cost close to $2,000,000, of which approximately $1,450,000 will be expended on project this year.

Va., Richmond—Virginia Electric & Power Co., Richmond, is arranging appropriation of about $650,000 for extensions and improvements in power plant and transmission system during 1938, including installation of additional equipment.